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Transportation Energy Contingency Planning:

Taxi and School Bus Use in Dallas-Fort Worth

August 1982

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Taxi and School Bus Use in Dallas-Fort Worth

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DEPARTMENT OF TRANSPORTATION
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Washington, D.C. 20590

In cooperation with
Technology Sharing Program
Office of the Secretary of Transportation

DOT-I-82-38

FOREWORD

Energy contingency planning continues to be an important aspect of urban transportation planning. Despite the fact that current energy supplies are more than adequate, the possibility for a disruption due to external factors remains. The urban transportation planning process thus ought to include activities aimed at maintaining mobility and providing alternatives in the event an energy emergency occurs.

While the decontrol of petroleum and ending of allocation controls and the possibility of State and local set asides has eliminated a variety of possible fuel supply oriented actions for States and local governments, a wide range of service and operational improvements remain. Many of these are also effective in non-emergency circumstances. Among these are use of taxicabs and school buses for paratransit services. This report synthesizes the experience of the Dallas-Fort Worth area in planning for the use of such vehicles in energy emergencies. We believe it will provide an important insight into the process an area would undertake to address development of such services. The report also highlights a number of important institutional issues likely to arise when taxicabs and school buses are considered for use in such circumstances. The report clearly demonstrates the need for contingency planning in advance of an emergency if these institutional barriers are to be successfully addressed.

This report represents one of a series entitled Transportation Energy Contingency Planning. Previous reports have covered Transit Fuel Supplies Under Decontrol (DOT-I-82-20) and A Practical Guide for Transit Operators (DOT-I-82-12). All are available through our offices, while supplies last, upon receipt of a self addressed mailing label. In addition, reports are available through the National Technical Information Service, Springfield, Virginia 22161. Please refer to UMTA TX-09-9003-82-1 when requesting this report.

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TABLE OF CONTENTS

		Page
	LIST OF EXHIBITS	iii
I.	EXECUTIVE SUMMARY	I-1
II.	INTRODUCTION	II-1
	Purpose	II-1
	Report Organization	II-2
III.	BACKGROUND	III-1
	Planning in North Central Texas	III-1
	NCTCOG Involvement with Energy Contingency Planning	III-3
	Brief Summary of Regional Plan	III-6
IV.	PARATRANSIT CONTINGENCY PLANNING	IV-1
	Overview of Study	IV-1
	Technical Effort	IV-1
	Institutional Considerations	IV-42
	Implementation Outlook	IV-56
V.	COMMUNITY TRANSIT ALTERNATIVES	V-1
	Overview of Study	V-1
	Technical Effort	V-2
	Institutional Considerations	V-42
	Outlook for Implementation	V-45
VI.	IMPROVEMENTS TO THE PLANNING PROCESS	VI-1
	NCTCOG Experience	VI-1
	Improvements to Energy Contingency Planning	VI-4
	Integration into the Planning Process	VI-6
	APPENDICES	
	Appendix A	A-1
	Appendix B	B-1

LIST OF EXHIBITS

Exhibit		Page
1	North Central Texas State Planning Region	III-2
2	Transportation Planning Orgnization, 1978	III-4
3	Taxicab Firms in the Dallas-Fort Worth Area, 1978	IV-3
4	Map of Ferguson Road Bus Route	IV-5
5	Distribution of Over-Capacity Runs	IV-6
6	Summary of Comparisons for Eight-Mile Route-Taxi Service with Auto	IV-9
7	Summary of Comparisons for Eight-Mile Route-Taxi Service with Bus	IV-10
8	Impact of Four Route-Taxis	IV-11
9	Extent of Over-Capacity	IV-12
10	Distribution of Over-Capacity Runs	IV-13
11	Extent of Over-Capacity	IV-14
12	Map of El Campo	IV-16
13	Boarding/Alighting Data for the El Campo Route	IV-17
14	Comparison of Modes for El Campo Route	IV-19
15	Garland Park-and-Ride Lots	IV-21
16	Energy Analysis	IV-23
17	Cost Analysis	IV-24
18	Map of Taxi Pool Routes	IV-26
19	Taxi-Pool Base Data	IV-28
20	Taxi-Pool Fixed and Variable Costs	IV-29
21	Taxi-Pool Total Costs and Costs Per Passenger	IV-30

22 Taxi-Pool Fuel Costs IV-31

23 Vehicle Productivity/Demand Density Regressions IV-34

24 Household Density Nomograph IV-36

25 Characteristics of Circulation-Taxi Subareas IV-37

26 Density/Sensitivity Analysis IV-39

27 Energy Analysis IV-40

28 Dallas-Fort Worth Retail Gasoline Price Increases IV-44

29 Fuel Cost Impact on Taxicab Operators in the Dallas-Fort Worth Area IV-46

30 Aggregate Taxicab Operating Statistics for Dallas-Fort Worth Area, 1978 and 1979 . . . . . IV-47

31 Aggregate Fuel Consumption Indicators for Taxicab Companies in the Dallas-Fort Worth Area IV-48

32 Average Taxicab Operating Expenses in Dallas-Fort Worth Area IV-49

33 Fare Structures IV-51

34 Methods for Alleviating Impacts of Higher Fuel Costs . . . IV-57

35 Peak Transit Coverage, Alternative #1 . . . . . V-9

36 Offpeak Transit Coverage, Alternative #1 . . . . . V-10

37 Community Bus Systems Impact-Incidence Matrix Alternative #1: Energy Conservation - Conventional Approach V-13

38 AISD Schools and Transportation Centers, Alternative #2 . . V-17

39 Community Bus Systems Impact-Incidence Matrix Alternative #2: Energy Conservation - Modified School Bus Routes V-18

40 Peak/School Bus Transit Coverage, Alternative #3 . . . . V-22

41 Offpeak School Bus Transit Coverage, Alternative #3 . . . V-24

42 Community Bus Systems Impact-Incidence Matrix Alternative #3: Energy Conservation - Combined Services . V-27

43 Community Bus Systems Impact-Incidence Matrix Alternative #4: Energy Contingency - Conventional Approach V-30

44 Community Bus Systems Impact-Incidence Matrix Alternative #5: Energy Contingency - School Bus Approach . V-36

45 Impacts of Alternative Service Designs V-40

46 Cost Effectiveness of the Community Bus Alternatives. . . V-41

I. EXECUTIVE SUMMARY

Since the disruption of energy supplies continues to be a possibility and a source of concern to transportation officials, the Urban Mass Transportation Administration has sponsored prototype planning studies addressing issues in contingency planning. This report compiles and summarizes such planning done by the North Central Texas Council of Governments (NCTCOG) involving the use of school buses and taxicabs in energy emergencies.

NCTCOG is the regional planning agency in the Dallas-Fort Worth metropolitan area. It is the staff element of the Metropolitan Planning Organization, with policy direction being provided by the Regional Transportation Council. The metropolitan area has a population in excess of 2.5 million in an area of approximately 2,600 square miles.

The Regional Transportation Council adopted an NCTCOG-developed regional transportation energy contingency plan in 1977. The plan had several wide-ranging recommendations which included continued investigation of the use of school buses and taxicabs in energy emergencies.

Taxicabs were analyzed from two perspectives. First, specific taxicab operations were examined for feasibility prospects. Second, the effect of gasoline price increases on taxicab service viability was determined. It was found that certain taxicab operations would be of benefit to the public during fuel shortages, provided that there was a profit incentive for individual owner-drivers to institute these services. In order to maintain a viable taxicab industry during periods of gasoline shortages and/or price increases, escalation clauses in taxicab rate ordinances were recommended.

As expected, the use of school buses for public transportation was found to be fraught with institutional issues, but there was optimism that these could be overcome. The NCTCOG prototype study provided considerable insight into how to approach these issues. Technically, the prototype case study concluded that the use of school buses could not be justified as a cost-effective approach toward fuel conservation. Integrating school buses into a public transportation system was found to be a cost-effective way to increase transit use, however.

It is recommended that fuel shortage considerations be incorporated into the ongoing urban transportation planning process. Planning for contingencies can be improved if more attention is paid to the motivating factors of the principal actors in a contingency scenario. Finally, the degree of self-determination extant in a community is a key determinant of the success of a contingency planning effort.

II. INTRODUCTION

PURPOSE

The possibility of a disruption in energy supplies continues to be of concern to transportation officials. Because such fuel emergencies can affect different communities in different ways, there is a need for locally developed transportation energy contingency plans which can provide for the mobility of the public during energy shortages.

Among those local organizations performing energy contingency planning is the North Central Texas Council of Governments (NCTCOG). NCTCOG is the Metropolitan Planning Organization for the Dallas-Fort Worth metropolitan area and completed an areawide, multimodal transportation energy contingency plan in September 1977. This initial plan identified, among other items, the need for additional work to better formulate the roles of taxicabs and school buses in providing mobility during energy emergencies. The Urban Mass Transportation Administration sponsored this school bus and taxicab assessment by the NCTCOG as one of a number of prototype planning studies addressing various issues in contingency planning.

Four major reports were developed under the NCTCOG prototype study:

1. Case Study of Community Transit Alternatives for Energy Shortages

2. Institutional Factors in a Case Study of the Use of School Buses in Energy Related Transportation Planning

3. Paratransit Energy Conservation in Contingency Study, Vol. 1: Paratransit Concept Analysis

4. Paratransit Energy Conservation and Contingency Study, Vol. 2: Regional Energy Costs Impacts on the Taxicab Industry

While these reports provided much useful analysis, they were not in a form which could be easily distributed and used by other public agencies. The purpose of this report is to synthesize the methods and findings of these study efforts into a single product for ready dissemination and use. Besides distilling these planning studies, this report provides the context in which these particular studies took place as well as some suggestions on how these procedures might be integrated into the transportation planning process.

REPORT ORGANIZATION

To fully understand the NCTCOG prototype study, it is necessary to appreciate the context in which the prototype effort was conducted. This background is provided in Section III.

The prototype study was actually conducted as several smaller studies. However, it is most convenient to describe the overall study in terms of two principal efforts: the paratransit energy contingency study and the community transit study. The paratransit energy contingency study effort is summarized in Section IV, while the community transit study is covered in Section V.

Section VI suggests means by which energy contingency planning can be integrated into an ongoing transportation planning process based upon the NCTCOG experiences. Recommendations are provided in this section.

III. BACKGROUND

PLANNING IN NORTH CENTRAL TEXAS

The North Central Texas State Planning Region includes the 16-county area surrounding the Dallas-Fort Worth metropolitan area (Exhibit 1). Multimodal transportation planning on a system basis is performed for the Intensive Study Area, defined as that area which is expected to be urbanized by 1990.

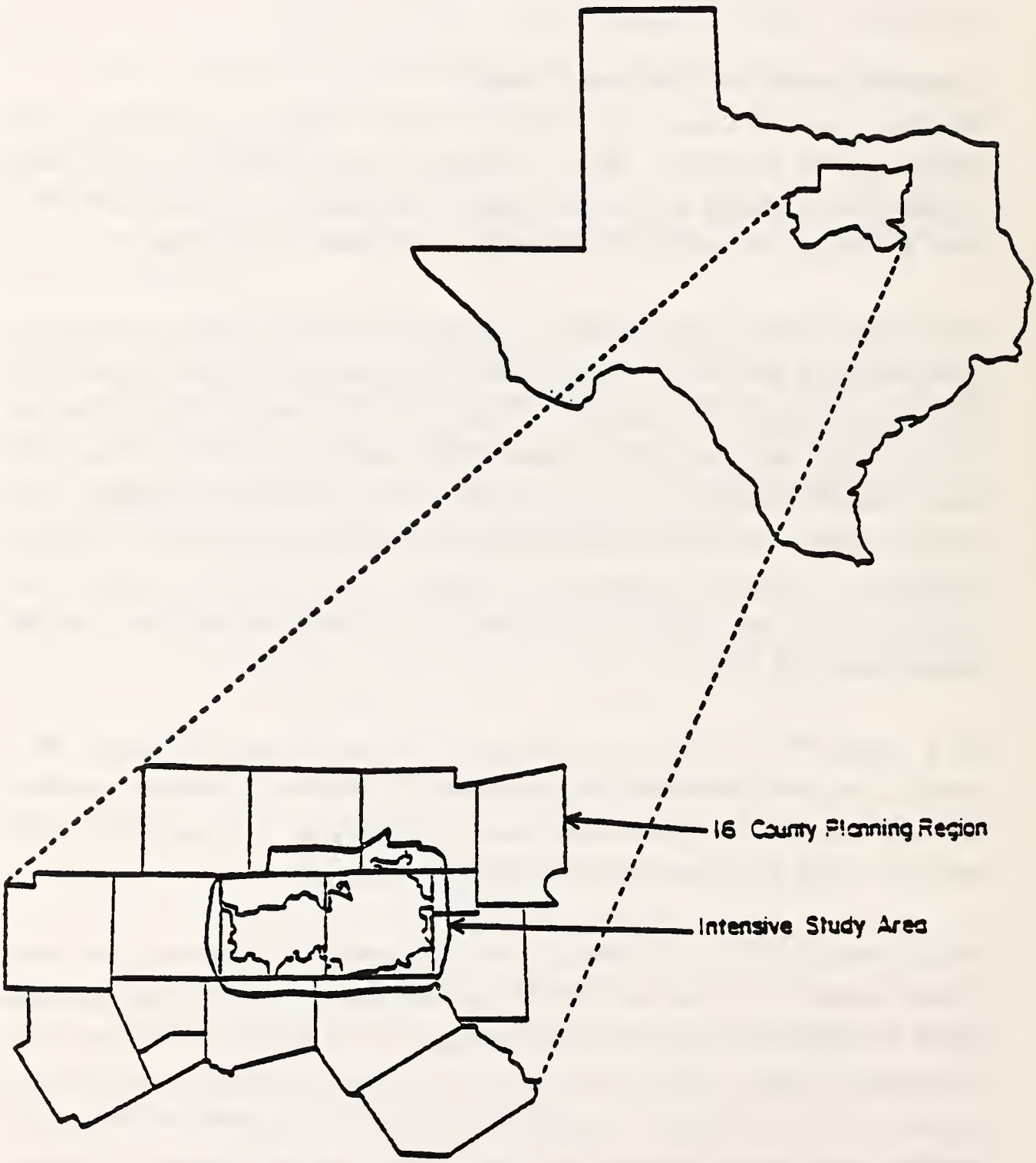
The Intensive Study Area consists of Dallas and Tarrant Counties plus parts of seven bordering counties for a total area of approximately 2,600 square miles. The Intensive Study Area contains 47 individual cities ranging in size from the City of Dallas with a population of over 900,000 and the City of Fort Worth with nearly 400,000 population to several cities of under 10,000 population. Six suburban cities — Arlington, Garland, Grand Prairie, Irving, Mesquite, Plano and Richardson — all have populations over 50,000. At the time the original energy contingency plan was completed, the population of the Intensive Study Area was approximately 2.5 million.

As a "sunbelt" urban area, the Dallas-Fort Worth metropolitan region has a strong automobile orientation with more than 10,000 miles of roadway, including over 400 miles of freeways, in the Intensive Study Area. In excess of 40 million vehicle miles of travel are experienced daily in the area.

Public transportation is provided by two city-owned bus systems: the Dallas Transit System in Dallas and CITRAN in Fort Worth. In a few places, these public transportation services extend into surrounding suburban cities, but this is the exception rather than the rule and in each case the suburban city pays the full cost of such services. A private bus company, Transportation Enterprises, provides local service between Fort Worth and Dallas on a regularly scheduled basis.

EXHIBIT I

NORTH CENTRAL TEXAS STATE PLANNING REGION



In 1978, there were 10 taxicab companies in operation in the Intensive Study Area. In general, these cab companies operated within city limits and served the major cities of Dallas and Fort Worth as well as the largest suburban cities.

Planning for regional transportation is accomplished by the organizational structure shown in Exhibit 2. The Metropolitan Planning Organization consists of two elements: the policy body, which is the Regional Transportation Council, and the staff, which is the North Central Texas Council of Governments.

The North Central Texas Council of Governments is a voluntary association of local governments. There are no state laws requiring participation in the Council of Governments or conformity with regional plans. Federal requirements for an A-95 review (which is also accomplished by the NCTCOG) and a transportation improvement program (TIP) are, of course, two federally required coordination processes. On rare occasions, the requirement for MPO approval of the TIP has been used by the Regional Transportation Council to resolve differences, but in general, the provision of a forum for the discussion of regional transportation issues has proved to be an effective coordination mechanism for local governments and state agencies.

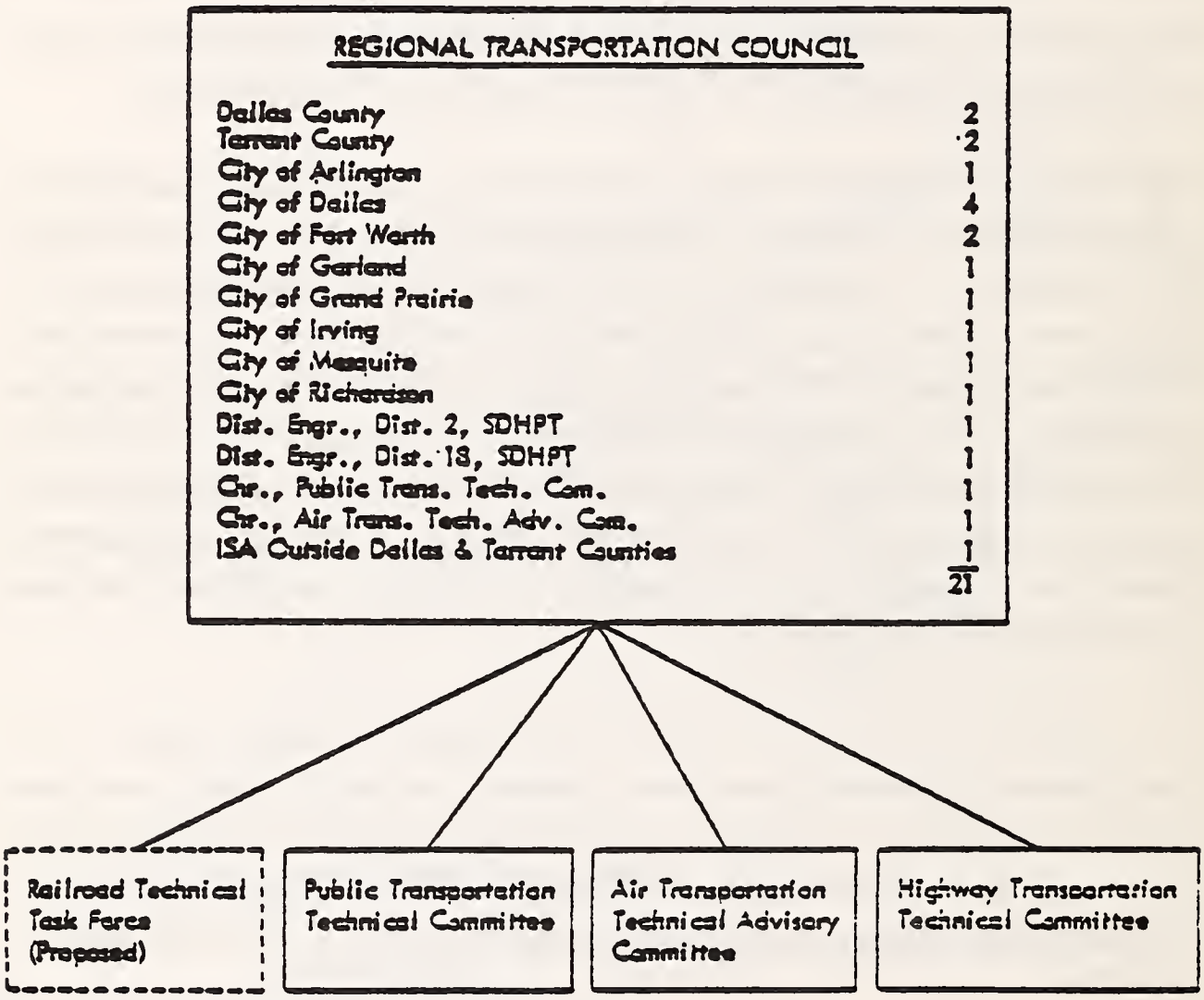
An important part of any NCTCOG transportation planning effort is the participation of technical committees. Energy contingency concerns have been primarily addressed in the Public Transportation Technical Committee, which consists of representatives from local governments, transit operators, the State Department of Highways and Public Transportation, and private transportation providers.

NCTCOG INVOLVEMENT WITH ENERGY CONTINGENCY PLANNING

The first major regional transportation study in North Central Texas to consider energy consumption was the 1990 Long-Range Transportation Plan approved in

EXHIBIT 2

TRANSPORTATION PLANNING ORGANIZATION, 1978



1974.[1] This long-range planning effort represented the culmination of several years of work. During calendar year 1974, this long-range planning effort was intensive, involving nearly the full-time participation of the entire transportation staff of NCTCOG. For continued certification of the planning process, the UMTA Regional Office had set the end of 1974 as a deadline for the completion of the 1990 plan for the region.

The timing of the 1973-74 oil embargo is important here. While the Arab oil embargo was imposed in October 1973, its effects were not felt in the United States until later in that year, and at that, these effects were isolated to the east coast. On November 25, President Nixon called for voluntary conservation measures including the Sunday closing of gasoline stations.

The institution of gasoline allocation by the Federal Energy Office in December of 1973 more evenly distributed the shortage across the United States. Difficulties in obtaining gasoline became apparent in the Dallas-Fort Worth area in March 1974, and it was shortly thereafter that the Regional Transportation Council began to receive presentations regarding the long-range plan alternatives. Ironically, no two alternatives differed by more than 2% in propulsive energy consumption.

By November of 1974, the Arab oil embargo had ended. However, gasoline prices were approximately 12¢ a gallon higher than they were a year before. Examination of the alternative transportation systems for 1990 had shown no apparent potential for significant energy consumption reductions. Questions were raised during the entire year of 1974 regarding the implications of future energy shortages on long-range transportation decisions, but because of the certification problem, these concerns were postponed until after the adoption of a long-range plan.

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[1] North Central Texas Council of Governments, Transportation Department, The Total Transportation Plan for the North Central Texas Region for 1990. Arlington, Texas. November 1974.

In March 1975, the mayor of the suburban city of Irving, acting as a member of the Regional Transportation Council, requested that the NCTCOG staff investigate further the implications of future energy shortages on the transportation system in the Dallas-Fort Worth area. In the State of Texas at the time, local governments had the authority to approve utility rates, and Mayor R. Dan Matkin was well aware of the uncertainty of future energy supplies based on presentations made to the Irving City Council for utility rate increases for electricity and natural gas.[2]

By the next Regional Transportation Council meeting in April, NCTCOG staff had prepared an overview of the national and local energy outlook.[3] This review suggested a need for both energy conservation in the long run and energy contingency planning in the short run. The Regional Transportation Council gave a higher priority to immediate energy contingency planning. This view, however, was by no means unanimous. One elected official on the Council felt that no energy plans should be made or implemented since the federal government would likely, at some point, require energy conservation thereby penalizing those organizations which took early energy conservation measures.

BRIEF SUMMARY OF REGIONAL PLAN

Since portions of the Dallas-Fort Worth energy contingency plan have been distributed by UMTA,[4] and a succinct summary distributed by the U.S.

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[2] R. Dan Matkin, "The Local Government Perspective" in Ann Rose (ed.), Proceedings of the Urban Transportation Energy Contingency Planning Seminar, Dallas-Fort Worth. North Central Texas Council of Governments. Arlington, Texas. November 1979.

[3] North Central Texas Council of Governments, Mobility and Limited Energy: Exploring Short-Range Possibilities. April 1975.

[4] Richard P. Steinmann, Michael Halladay, T. Masog (eds.), Transportation Energy Contingency Planning: Local Experiences. U.S. Government Printing Office. Washington, D.C. June 1979. DOT-UMTA-TX-09-9001-79-1.

Department of Transportation's Technology Sharing Office,[5] only a brief summary of the NCTCOG plan will be presented here.

The basic approach of the NCTCOG regional energy contingency planning study was to: (1) develop alternative energy shortage scenarios, (2) identify anticipated local problems, and then (3) suggest actions which would ameliorate these difficulties. In order to accomplish this, trends in national energy supplies and consumption were examined, and investigations were made of the impact of the 1973-74 oil embargo on local as well as national travel. From this it was assumed that a shortage of up to 25% could be anticipated. An overall increase in the demand of transit service of 40% was projected under the worst conditions.

Assuming that the federal government would implement a policy of fuel allocation or rationing in order to distribute any national fuel shortage evenly across the country, there seemed to be four basic problems which would need to be resolved:

1. Public transportation operators would need to obtain sufficient fuel not only to maintain current operations but also to provide additional service in order to meet increased demand

2. The increased demand for mass transit service would be difficult for the public transportation operators to deal with

3. Some form of transportation alternative to the private automobile would be greatly needed in the suburban areas where no public transportation services currently existed

4. Strategies were needed to reduce the inequities and uncertainties associated with gasoline rationing and allocation at the local level

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[5] William G. Barker and Lawrence C. Cooper, "An Approach to Transportation Planning for National Energy Contingencies." January 1978.

Taxicabs and school buses were viewed as transportation resources which could be used to assist in two of these problem areas: coping with additional mass transit ridership and providing alternative transportation services in suburban areas. The concept of a "route taxi," for example, was analyzed in the plan. It was envisioned that these taxi routes would radiate from the central business district to the expected maximum load points on the transit routes. In the City of Dallas it was estimated, a route taxi service could accommodate one-third to one-half of the expected overload on the Dallas Transit System.

Clearly, a taxicab-based service could also be of benefit in suburban areas. However, many suburban areas had no taxicab service and in others service was limited at best. It appeared, therefore, that school buses would offer much more potential in a suburban setting than did taxicabs. The plan pointed out that although current state law prohibited the use of school buses for general transportation purposes, it was conceivable that this could be changed and that several possibilities existed:

- Allowing school buses to serve the general public only during those hours in which they were not in school service
- Allowing the general public to board buses along normal or slightly modified school bus routes during school use
- Using school buses as shuttles or feeder service to fixed transit lines or park-and-ride lots
- Using some school buses to provide special trips, say to major employment centers
- Appropriating school bus fleets for public transportation service

A concept briefly analyzed in the plan was the provision of general public transportation service by school buses while most of the school fleet continued to transport students. It was envisioned that the school district could utilize fewer buses by modifying routes to require the students to walk farther to the bus stops. The suburban city of Arlington was used as a case study.

Assuming different minimum walking distances, from 8 to 18 school buses out of the total Arlington school district's fleet of 50 buses could be used for general transportation purposes by requiring more walking by students. It is significant to note that at that time, the public transportation plan under development by the City of Arlington called for a city bus fleet of only 12 transit vehicles; thus the school bus concept seemed very promising for suburban areas. The NCTCOG plan acknowledged, however, that ". . .institutional difficulties involved with alterations to the structure and purpose of the school bus transportation system" would be a major obstacle to implementation.

Based on the analyses in the NCTCOG planning study, the recommendations included establishing priority fuel allocation for taxicabs during fuel emergencies because of their potential for providing expanded mobility; modifying the state law to permit the public use of school buses; investigating the role of and impact on taxicabs in an energy shortage; and developing draft contingency agreements with transportation operators, local governments, and school districts to provide during an energy emergency the kind of services discussed.

It is on this basis, therefore, that further studies of the role of paratransit and school buses in an energy contingency were viewed as promising.

IV. PARATRANSIT CONTINGENCY PLANNING

OVERVIEW OF STUDY

Although previous NCTCOG energy contingency planning had identified taxicabs as a potentially important transportation resource during a fuel shortage, this form of paratransit was found to be particularly vulnerable to fuel prices and shortages. NCTCOG's regional energy contingency plan recommended that a "route taxi" plan be developed to supplement transit service, particularly in Dallas, in the event of future fuel shortages. It was also recommended that the impact of higher fuel prices on the area's taxicabs should be investigated.

The prototype paratransit energy study which followed from the energy contingency plan recommendations analyzed five specific paratransit concepts in the Dallas-Fort Worth metropolitan area. The five concepts investigated were --

- route taxis
- transit taxis
- feeder taxis
- taxi pools
- circulation taxis

Although the initial NCTCOG planning effort had suggested route taxis in the central area of Dallas in order to alleviate the overloaded transit system, it was decided to investigate other possible taxi uses during an energy shortage. In addition, since this was a regional planning effort, it was desirable to study these different paratransit concepts in different parts of the region rather than focusing entirely on central Dallas.

In 1978 there were 10 taxicab companies in operation in the Dallas-Fort Worth metropolitan area (Exhibit 3). Most of these were small, independent operations serving a limited geographical area. It became clear during the energy contingency planning study that these small taxicab operations would have a great deal of difficulty during energy shortages due either to the lack of fuel or to the rapid increases in the price of fuel. Thus, a separate study, distinct from the taxi concepts analysis, was done on the impact of higher fuel costs on area taxicab firms. The objective of this second study was also to suggest methods for alleviating any adverse impacts and to assess the ease of implementation and general feasibility of such methods.

Although these were undertaken as two separate studies, they were in fact done by the same technical consultant. The results of the two studies were documented separately.[6] Much of this material is directly reproduced in the following summary.

TECHNICAL EFFORT

In 1978, there were a total of 10 taxicab companies operating in the metropolitan area. These operations had a total estimated taxicab fleet of 737 vehicles.

Paratransit Concept Analysis

As mentioned previously, the consultant analyzed the feasibility of five specific paratransit concepts for the North Central Texas region. These five concepts were —

- route taxis
- transit taxis
- feeder taxis
- taxi pools
- circulation taxis

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[6] Ernst & Whinney, Paratransit Energy Conservation and Contingency Study, Volume I: Paratransit Concept Analysis, Volume II: Regional Energy Cost Impacts on the Taxicab Industry. Prepared for the North Central Texas Council of Governments. April 1980.

EXHIBIT 3

TAXICAB FIRMS IN THE DALLAS-FORT WORTH AREA
1978

Company	Number of Cars	Cities*
City Cab of Arlington and Grand Prairie	15	Arlington, Grand Prairie
Fort Worth Cab and Baggage	66	Benbrook, Carswell Air Force Base, Forest Hill, Fort Worth, Haltom City, Richland Hills, North Richland Hills, River Oaks, Sansom Park Village, White Settlement
Mesquite Cab	2	Mesquite
Metroplex Cab	2	Hurst, Bedford, Euless, Grapevine
Metropolitan Transportation Service	21	Irving
Poor Boy Cab	12	Fort Worth
State Cab	9	Dallas
SUNTRAN Taxi	100	D/FW Airport
Terminal Cab	164	Dallas, D/FW Airport
Yellow Cab of Dallas	346	**Carrollton, Dallas, D/FW Airport, **Farmers Branch, Garland, **Highland Park, Richardson, Texas Stadium in Irving, University Park
TOTAL	737	

*Cities in which the company has a specific franchise or other authority to operate.
**Service is provided in these cities but no formal authority has been given the taxicab company.

Source: William G. Barker, Lawrence C. Cooper, Susan Wade, and Anne Rose. A Survey of Paratransit and Related Operations in the Dallas-Fort Worth Area. NCTCOG, Arlington, Texas. December 1979.

Route Taxi Concept

A route taxi is a taxi vehicle that follows a fixed route paralleling or duplicating a transit route. It operates in a shared-ride mode acquiring and discharging passengers along the route. Route taxis provide the flexibility to increase transit service on short notice and to serve high ridership such as might occur during an energy shortage.

In order to analyze the route taxi potential in the North Central Texas region, the Ferguson Road route (No. 64) of the Dallas Transit System was selected (see Exhibit 4). It operated over an 11.2 mile long (one-way) route serving a corridor in Northeast Dallas. Service on this route cost $1.75 per bus mile or $27.22 per bus hour. Average bus speed was 15.8 miles per hour.

During the peak hours, the route was actually divided into two segments as indicated in the exhibit. The Ferguson Short Line provided local service over the half of the route located closer to downtown. The Ferguson Road route provided express service over this portion but local service over the outlying half of the route.

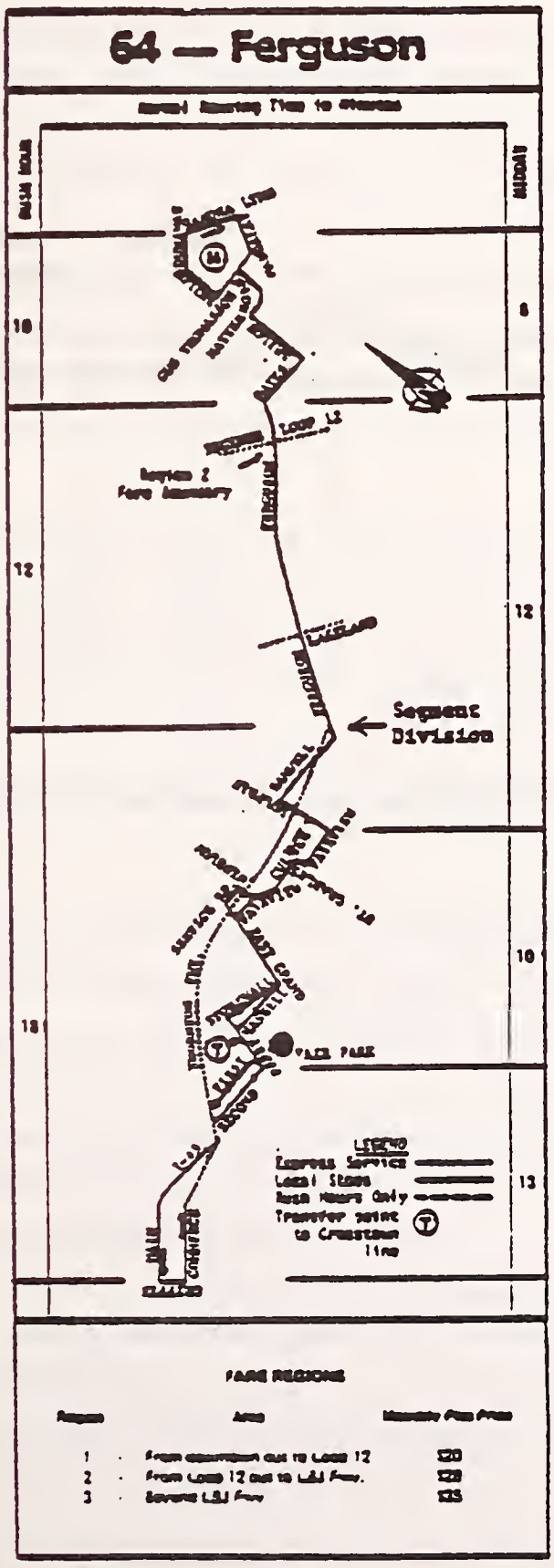
DTS had suggested this particular route for analysis because its outlying portion was characterized by over-capacity ridership. Of 94 runs sampled on June 27 and July 12 of 1979, 50 runs exceeded the standard capacity of 56 passengers. Exhibit 5 details the nature of this over-capacity problem.

It was important to analyze different options for coordinating the taxi service and the bus service. There were several options, three of which were analyzed by the consultant.

In the first option, the taxis would follow certain buses along the Ferguson Road route, picking up excess passengers unable to board the bus. The principal problem here was that the taxi would probably run faster than the bus service and hence, might attract passengers away from the bus. While this could possibly

EXHIBIT 4

MAP OF FERGUSON ROAD BUS ROUTE



SOURCE: Dallas Transit Route Schedule

EXHIBIT 5

DISTRIBUTION OF OVER-CAPACITY RUNS

NUMBER OF RUNS

No. of Excess Passengers	Morning		Evening	
	June 27	July 12	June 27	July 12
1-5	1	6	9	6
6-10	1	5	2	2
11-15	0	3	1	2
16-20	6	1	1	1
21-25	1	0	0	0
26-30	2	0	0	0

have been overcome by requiring the taxi always to follow the bus, there remained the logistical question of calling in additional taxis when the first taxi became full.

A second option was for the route taxis to provide service only at selected points along the Ferguson route. Taxis would wait at these points and serve those passengers unable to board the buses. A variation of this option was to determine the maximum load point along the bus route. Buses would then travel express from this point to the CBD or from a maximum load point near the CBD to the suburb. Remaining stops were to be serviced by the route taxis. This option had several advantages. First, it was simpler for both the passengers and operators because of the fixed limits to local bus and local taxi route services. It also made it easier to provide the necessary number of cabs at this point.

A third option was to run the taxi service strictly on a demand-responsive basis. A bus driver unable to pick up passengers from a bus stop would radio the dispatcher who, in turn, would dispatch a cab to that location. This approach had major disadvantages. The time for the taxi to arrive might be excessive; in fact, the next bus could arrive before the route taxi. Also it was been more complicated operationally and more difficult to group passengers from different bus stops into one cab.

On the basis of the above descriptions, the fixed-point service was preferable. Comparisons of cost, fuel consumption, and other factors were made between route taxi service and the same service by bus or individual travel by automobile.

For this comparison, the following assumptions were made:

- route length (one way) = 11.2 miles
- overcrowding confined to 8 miles of route
- auto fuel = 12 miles per gallon (local) and 16 miles per gallon (express)
- taxi fuel = 10 miles per gallon (local) and 14 miles per gallon (express)
- auto costs = $.25/mile
- taxi costs = $.70/mile with no flag drop charge

- auto occupancy = 1.4 persons per car
- taxi occupancy = 5 persons per car (plus driver)
- parking costs = $1.80 per day
- bus speed = 15.8 miles per hour
- taxi speed (local) = 19 miles per hour
- taxi speed (express) = 29 miles per hour
- bus fuel = 4 miles per gallon
- bus costs = $1.75 per mile

The summary of comparisons of the route taxi with the automobile is shown in Exhibit 6. Four autos were required to replace one taxi on the road using the average of 1.4 persons per auto, and, on this basis, the route taxi compared favorably with the automobile. On a per passenger basis for the 8-mile route, the fuel consumption for an automobile round trip was .84 gallons, versus .24 gallons for the taxicab. The cost by automobile on a per person basis for the 8-mile route was $4.64, as compared to $2.24 by the route taxi. Thus, the route taxi was less costly to operate and consumed less fuel than the private automobile in meeting the same demand.

As for the comparison between the route taxi and the bus, the results are shown in Exhibit 7. From this information it can be seen that the attractiveness of the route taxi concept depended upon which measures were of greatest concern. During times of acute fuel and bus shortages, capacity may be more important than cost.

Using the available data for June 27 and July 12, the effectiveness of route taxis in providing additional capacity was analyzed. Assuming four route taxis in service on those days, the taxis could have served only 44% of the 419 over-capacity passengers. There was, however, a large difference between the percentages of these people served on each of the two days as shown in Exhibit 8.

Under energy shortage conditions, it was expected that more standees would be on the bus and so the definition of bus capacity was changed to 64 passengers. Exhibits 9 through 11 show the incidence of excess demand using this more liberal definition.

EXHIBIT 6

SUMMARY OF COMPARISONS FOR EIGHT-MILE ROUTE-TAXI SERVICE WITH AUTO

Measure	Number of Autos to Replace Taxis				Number of Taxis in Service			
	4	8	11	15	1	2	3	4
Fuel (gallons)								
• one-way	2.08	4.16	5.72	7.8	.6	1.2	1.8	2.4
• round-trip	4.16	8.32	11.44	15.6	1.2	2.4	3.6	4.8
Cost (dollars)								
• one-way	$15.20	$30.40	$41.80	$57.00	$ 5.60	$11.20	$16.80	$22.40
• round-trip	$32.20	$46.40	$63.80	$87.00	$11.20	$22.40	$33.60	$44.80
Passengers	5	10	15	20	5	10	15	20

EXHIBIT 7

SUMMARY OF COMPARISONS FOR EIGHT-MILE ROUTE-TAXI SERVICE WITH BUS

Measure	Number of Taxis in Service				Bus Serving Only 8 Miles of Route	Bus Serving All 11.2 Miles of Route
	1	2	3	4		
Travel Time (one-way, minutes)	17.6	17.6	17.6	17.6	30.4	42.5
Fuel (gallons)						
• one-way	0.6	1.2	1.8	2.4	2.0	2.8
• round-trip	1.2	2.4	3.6	4.8	4.0	5.6
Cost (dollars)						
• one-way	$5.60	$11.20	$16.80	$22.40	$14.00	$19.60
• round-trip	$11.20	$22.40	$33.60	$44.80	$28.00	$39.20
Capacity	5	10	15	20	56	56
Fuel Use Per Passenger (gallons)	.12	.12	.12	.12	.04	.05
Cost Per Passenger	$ 1.12	$1.12	$ 1.12	$ 1.12	$.25	$.35

EXHIBIT 8

IMPACT OF FOUR ROUTE-TAXIS

	June 27		July 12		Total	
Excess Bus Passengers						
AM Peak	156		113		269	
PM Peak	75		75		150	
Total	231		188		419	
Excess Bus Passengers Served by Route Taxi						
AM Peak	27	(17%)	63	(56%)	90	(33%)
PM Peak	40	(53%)	56	(75%)	96	(64%)
Total	67	(29%)	119	(63%)	186	(44%)

EXHIBIT 9

EXTENT OF OVER-CAPACITY
(64 Passenger Bus Capacity)

	June 27, 1979		July 12, 1979	
	Number of Runs	Excess Passengers	Number of Runs	Excess Passengers
Morning Peak	10	125	5	23
Evening Peak	3	18	5	19

EXHIBIT 10

DISTRIBUTION OF OVER-CAPACITY RUNS
(64 Passenger Bus Capacity)

NUMBER OF RUNS

No. of Excess Passengers	Morning		Evening	
	June 27	July 12	June 27	July 12
1-5	1	3	2	4
6-10	2	2	0	1
11-15	4	0	1	0
16-20	1	0	0	0
21-25	2	0	0	0

EXHIBIT II

EXTENT OF OVER-CAPACITY
(64 Passenger Bus Capacity)

	June 27, 1979		July 12, 1979	
	Number of Runs	Excess Passengers	Number of Runs	Excess Passengers
Morning Peak	60	23	65	0
Evening Peak	15	18	3	1

In general it was found that —

1. The route taxis could serve as many as 1,100 passenger miles per day which could not have been served during a contingency situation.
2. The route taxi concept was more cost efficient and fuel efficient than using private automobiles to meet the excess demand.
3. The assumed bus capacity was of great importance in assessing the route taxi concept. For the more restrictive 56 passenger capacity, the route taxis provided service to 51% of the excess passengers. For the 64 passenger capacity, the percentage serviced increased to 63%.
4. There was considerable variability in the distribution of patrons who exceeded the capacities of the bus service. It is clear, however, that the route taxi concept did provide additional mobility.
5. The route taxi was, therefore, a feasible concept to implement during an energy contingency.

Transit - Taxi Concept

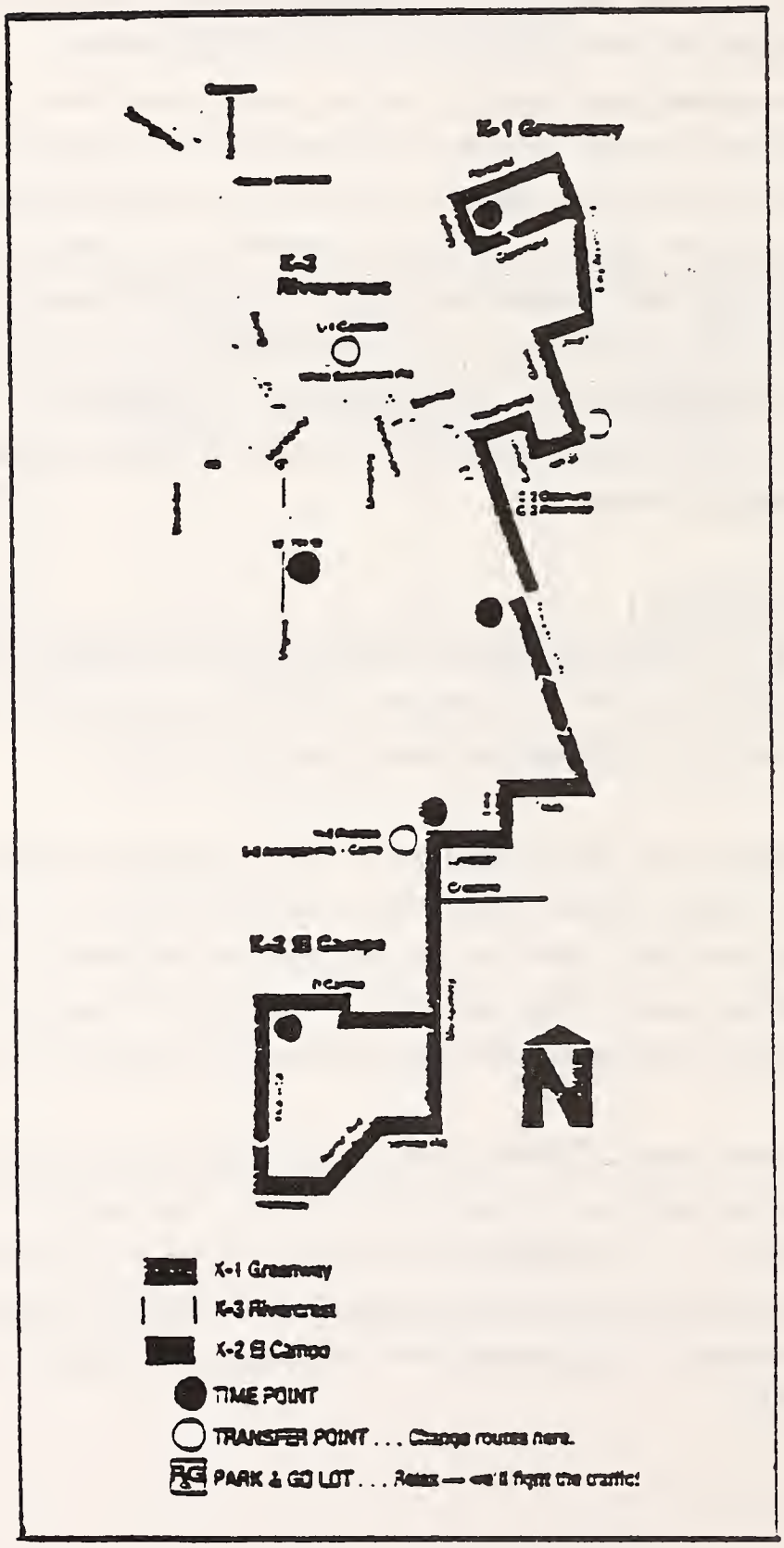
In the event of an energy shortage, it might be a good strategy to totally replace an entire transit route with taxi service. This is the transit-taxi concept which was analyzed for the El Campo bus route in west Fort Worth.

CITRAN operated the El Campo route from downtown Fort Worth along Throckmorton Avenue to El Campo Avenue (see Exhibit 12). The route was 5.15 miles in length one way. The cost per bus mile was estimated at $1.71 and the fuel consumption was 4 miles per gallon. During the peak hours two buses operated over the route, while during the mid-day only one bus was operated.

In support of this study, CITRAN performed a boarding and alighting check on the El Campo bus route on Monday, July 30, 1979. The results of this check are shown in Exhibit 13. The exhibit also shows the number of buses operating for each run, and, based on the maximum passengers on board, the estimated number of taxicabs needed. It was assumed that five passengers could be accommodated by each taxicab.

EXHIBIT 12

MAP OF EL CAMPO



Source: CITRAN

EXHIBIT 13

BOARDING/ALIGHTING DATA FOR THE EL CAMPO ROUTE
July 30, 1979

Run	Average Passengers On Board	Maximum Passengers On Board	Maximum # of Cabs Needed	Number Of Buses Operating
6:49- 7:12	11	16	4	2
7:12- 7:58	6	15	3	2
8:15- 8:34	6	10	2	2
8:35- 9:20	7	11	3	2
9:39-10:00	5	7	2	1
10:25-10:54	11	13	3	1
10:59-11:58	6	8	2	1
12:00-12:52	6	8	2	1
1:01- 1:57	7	14	3	1
1:59- 2:50	5	9	2	1
2:51- 3:34	8	14	3	2
3:35- 4:27	6	19	4	2
4:38- 5:19	17	25	5	2
5:20- 5:58	21	29	6	2
5:58- 6:07	16	18	4	2

A comparison of transit taxis to bus service and individual automobiles was made and is summarized in Exhibit 14. The assumptions used in these calculations were —

- o route length (one way) = 5.15 miles
- o bus costs = $1.75 per mile
- o taxi costs = $.70 per mile
- o bus fuel = 4 miles per gallon
- o taxi fuel = 10 miles per gallon
- o travel time for the transit-taxi assumed to be the same as the bus
- o auto fuel = 12 miles per gallon
- o auto costs = $.25 per mile
- o parking costs = $1.60 per day

Based on this analysis, the following conclusions were reached by the consultant:

1. The best overall option in terms of fuel efficiency and cost per trip was the operation of two transit taxis for every one bus. This option, however, was cost and energy efficient only if the demand was ten or less. Beyond this number of taxis, the bus was more efficient. Transit taxis were still more efficient than the private automobile.
2. In the event of an energy shortage, when buses might not be available, the utilization of transit taxis was a more cost - and energy - efficient mode of transportation than the private automobiles. They could help meet the mobility needs of the public during an energy emergency.
3. In a contingency, the El Campo route was a logical choice for the implementation of transit taxis. The buses taken off this route could be utilized on high demand routes. These two buses could have provided an additional 450 person trips during the peak period if placed on a route the same length as El Campo. The transit taxi was an effective substitute for the bus on routes similar to El Campo in the event of an energy shortage.

EXHIBIT 14

COMPARISON OF MODES FOR EL CAMPO ROUTE

Measure	1 Cab	2 Cabs	3 Cabs	1 Bus	4 Autos	7 Autos	11 Autos
Fuel (gallons)							
• One-way	.52	1.04	1.56	1.29	1.72	3.01	4.73
• Round trip	1.04	2.08	3.12	2.58	3.44	6.02	9.46
Cost							
• One-way	$3.61	$ 7.22	$10.83	$ 9.01	$11.56	$20.23	$31.79
• Round trip	$7.22	$14.44	$21.66	$18.02	$16.72	$29.26	$45.98
Occupancy	5	10	15	15	1.4	1.4	1.4
Fuel Use per Passenger (gallons)	.104	.104	.104	.086	.31	.31	.31
Cost Per Passenger One Way	$ .72	$ .72	$ .72	$ .60	$ 2.12	$ 2.12	$ 2.12

Feeder Taxi Concept

The feeder taxi concept involves the use of shared-ride taxis to transport persons to and from transit terminals such as park-and-ride lots. ·The City of Garland (a large suburban city northeast of Dallas) was planning a paratransit service which could include feeder service to two park-and-ride lots, using a fleet of three sedans and four vans. This situation served as the basis of a feeder taxi analysis.

The feeder service envisioned was to operate in two sectors: one centered around the North Garland lot and one around the South Garland lot, as indicated in Exhibit 15.. Service would be provided for Garland residents to and from the lot nearer to each passenger's residence. In the morning, a vehicle, either a van or a sedan, would pick up residents and take them to the nearest park-and-ride lot in time to meet a specific bus departure. The normal mode of operation would be a subscription service, although changes in standing orders, e.g., taking a later bus, could be accommodated. Although not examined in this analysis, such non-subscription requests might have required a higher fare.

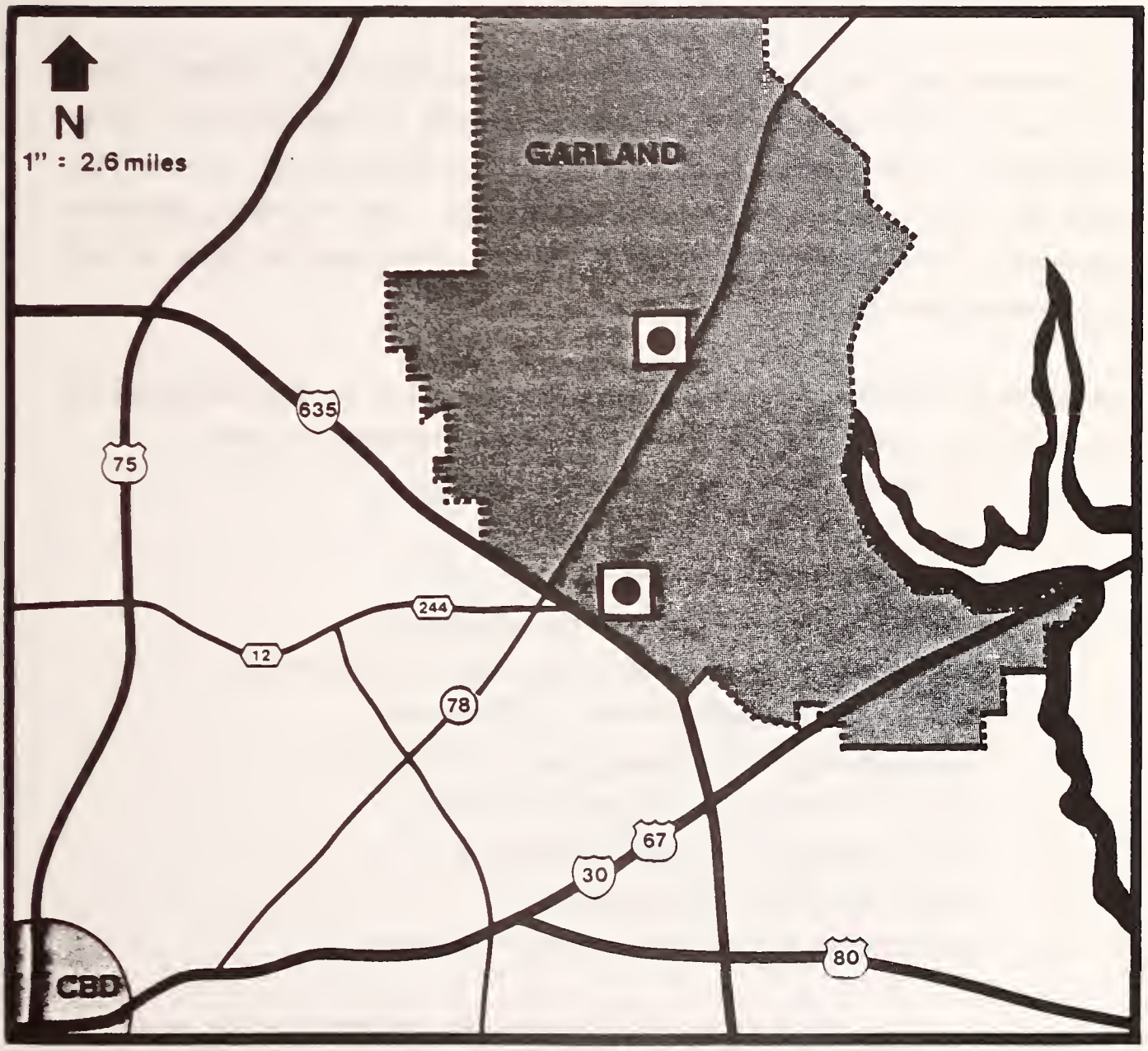
In the afternoon, the service would be more flexible in order to allow persons to catch a later or earlier bus from downtown Dallas. It was recommended that radio contact between the Dallas Transit express buses and Garland taxi dispatcher be established in order for the paratransit operator to prepare for the number of passengers disembarking at each of the two lots. The vehicles waiting at each lot would be designated by the area of Garland to be served by each vehicle. Passengers would, therefore, group themselves according to common geographical destination.

In order to analyze the energy use and costs of feeder taxi service, it was necessary to be more specific about how efficient the routing would be. Using data from an NCTCOG park-and-ride lot license plate survey, the distribution of distances for park-and-ride users was available for a Garland park-and-ride lot.

The maximum productivity of the feeder service occurred when all of the passengers lived in one place. If a five-passenger sedan was used, it was assumed that the sedan would drive from the park-and-ride lot to the pick-up point and

EXHIBIT 15

GARLAND PARK-AND-RIDE LOTS



Park and Ride Lots

bring the five passengers back to the park-and-ride lot. In this case, the passenger miles per vehicle mile was 2.5. Using a similar analysis, a twelve-passenger van, if all twelve passengers boarded at the same location, could achieve a productivity of 6.0.

On the other hand, the lower bound on the feeder productivity depended on the willingness of individuals to ride for extended periods in order to pick up other passengers. It was assumed that no passenger would be willing to more than double his or her trip time to use the feeder service. This assumption yielded a passenger-mile per vehicle-mile figure of 1.67 for a five-passenger sedan and 4.0 for a twelve-passenger van.

The consultant compared the feeder taxi service against an auto park-and-ride and an auto kiss-and-ride option. The following assumptions were used:

- fuel efficiency for taxis and vans = 10 mpg
- fuel efficiency for autos = 16 mpg
- fuel costs = $1.00 per gallon
- cold start efficiency = 59% normal efficiency
- distribution of trip distances same as for NCTCOG survey
- cost for van or sedan operation = $.70 per mile
- auto operating cost excluding fuel = $.054 per mile
- vehicle occupancy for auto park-and-ride = 1.4
- vehicle occupancy for auto kiss-and-ride = 1.0
- vehicle occupancy for taxi feeder = 5
- vehicle occupancy for van feeder = maximum of 12

The analysis was done for the highest efficiency case described earlier, as well as the lowest efficiency case. These results are shown in Exhibits 16 and 17. In each instance the operating range for the feeder taxi and feeder van was that defined by the upper and lower productivity bounds as discussed above. As far as energy efficiency (Exhibit 16) is concerned, the five-passenger vehicle, when serving the maximum passengers, was more energy efficient than all of the auto options except the unlikely auto park-and-ride under warm conditions.

EXHIBIT 16

ENERGY ANALYSIS

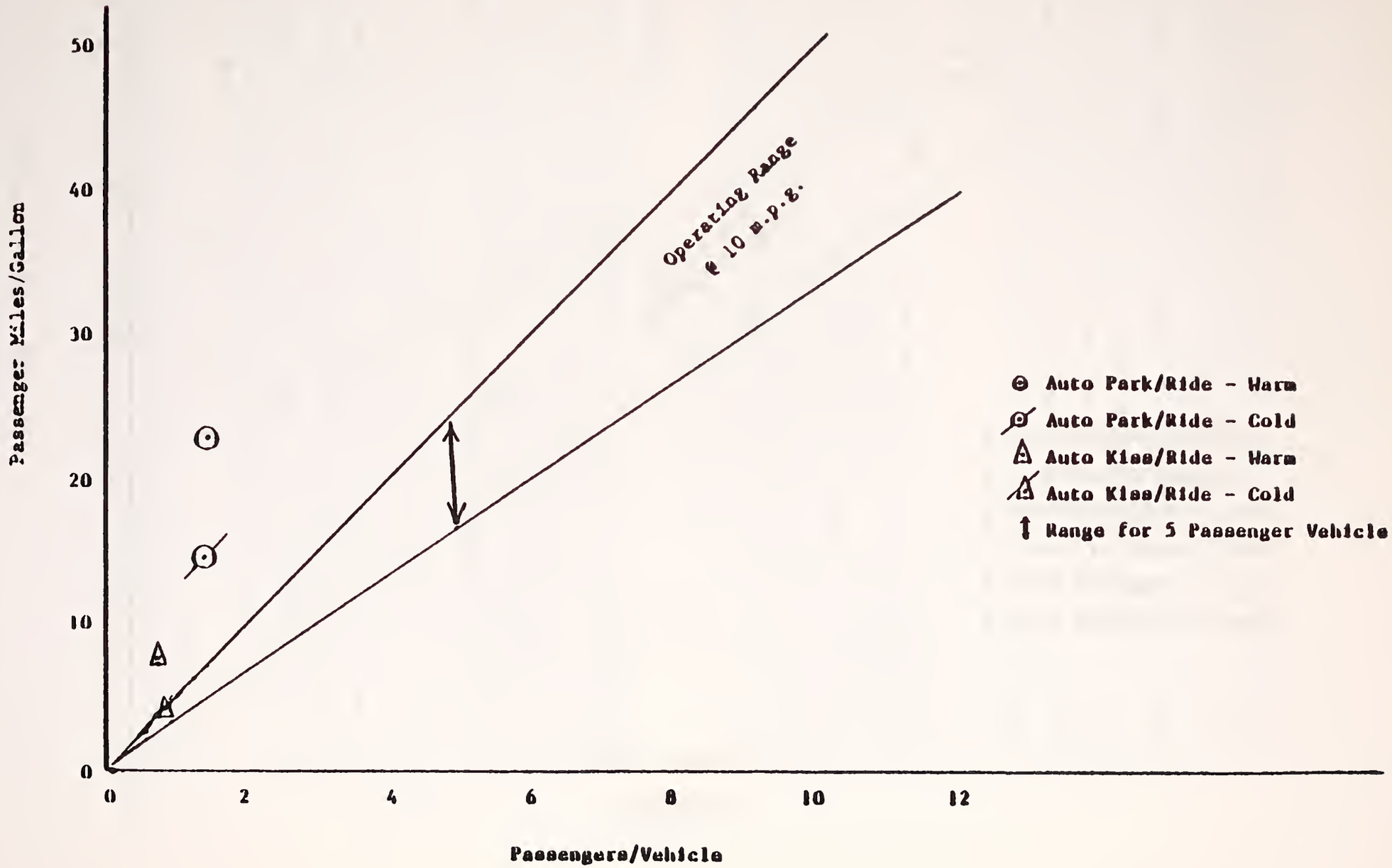
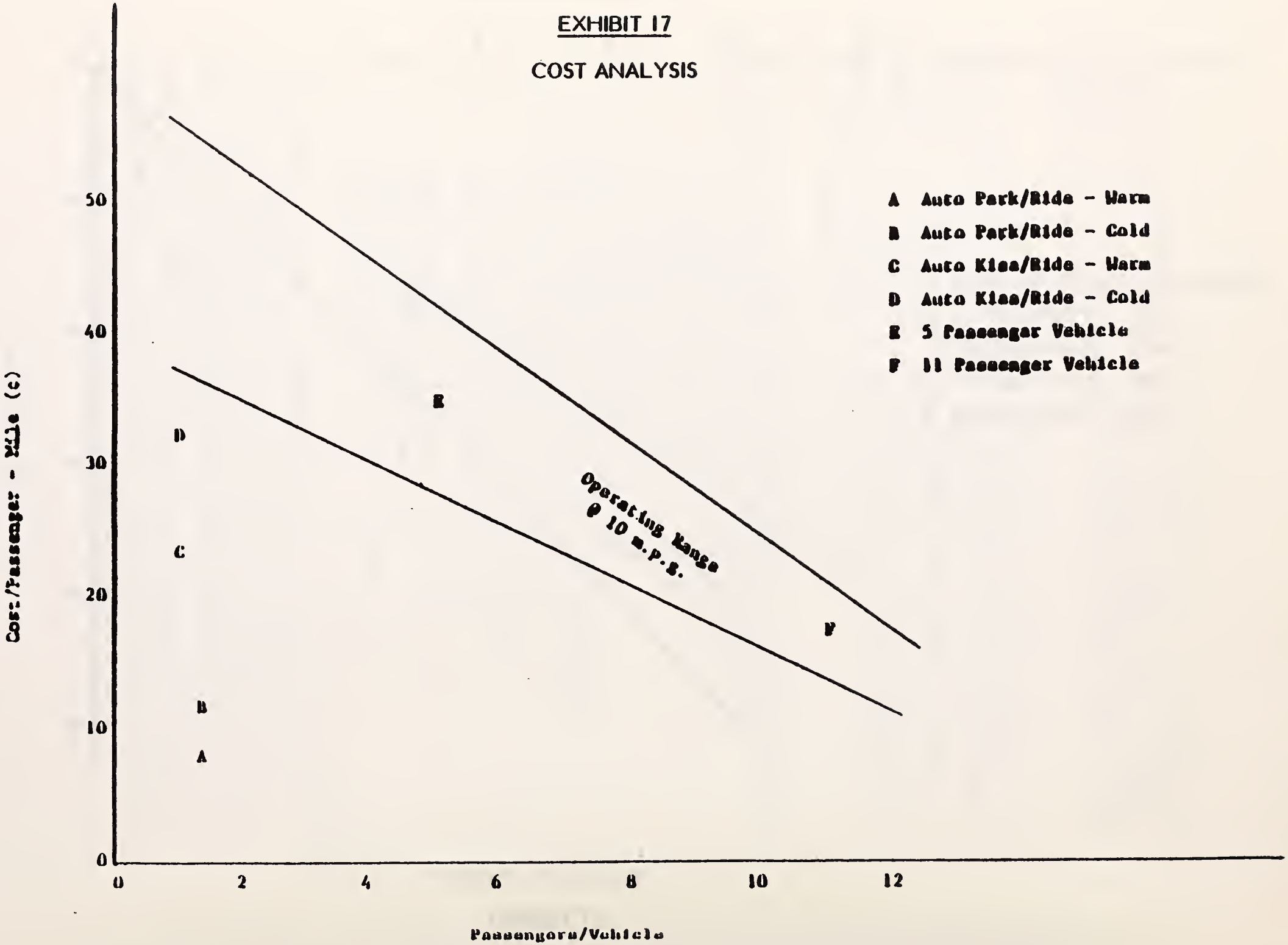


EXHIBIT 17

COST ANALYSIS



From a cost standpoint, however, the auto park-and-ride was the least costly on a per passenger basis, even under cold start conditions (Exhibit 17). The kiss-and-ride option was less costly than a five-passenger feeder trip, depending on the cold start conditions and the amount of collection and distribution feeder mileage. However, for the larger capacity vans, the comparison favored the feeder van. For example, even if the van transported only 11 people, it was less costly than the kiss-and-ride option regardless of the circumstances. If all the people were picked up at one location, the trade-off point occurred at only 7 persons per trip.

Overall, the conclusions were that the taxi feeder was a highly feasible energy contingency service. It could be implemented without using large buses and hence was not subject to the unavailability of these buses. It had demonstrable energy savings over auto service and was highly recommended. Great savings in energy resulted from passengers walking to a common pick-up point. This option was encouraged wherever possible.

Taxi Pool Concept

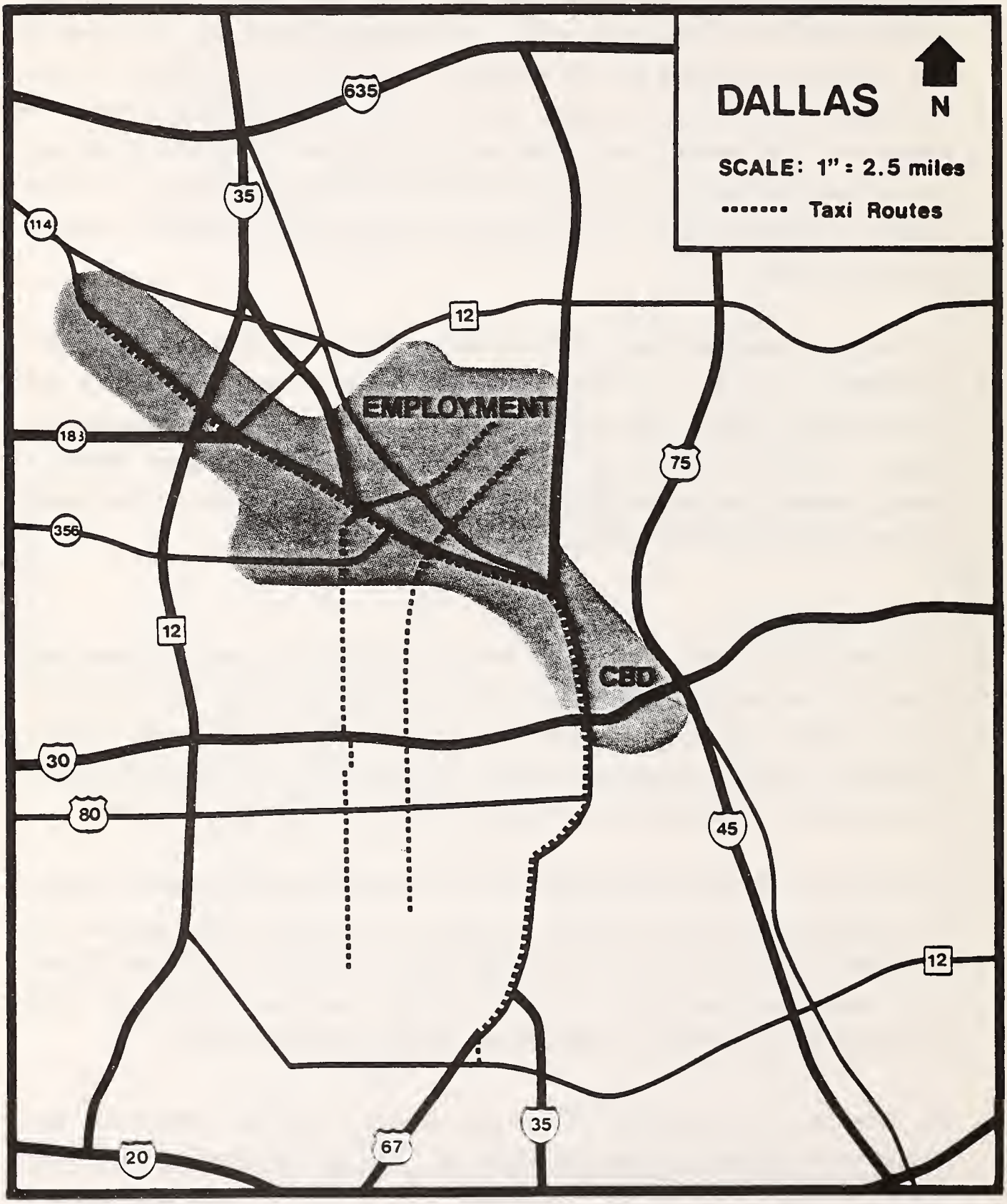
The concept of a taxi pool is similar that of a car pool or a van pool, except the driver and the service are hired rather than provided by one of the commuters. A taxi pool's role in an energy crisis would be to provide people with an alternative mode of transportation over the automobile. The best locations for such a service would probably be in those areas with no existing bus service.

The taxi pool concept was investigated for a particular situation found in Dallas. A prototype service was modeled to connect the industrial area between the Stemmons Freeway and Harry Hines Boulevard, northwest of downtown Dallas, with residential areas south of this industrial area (see Exhibit 18). This particular travel corridor was not well served by existing bus service.

To determine the parameters of taxi pool service in this area, three line haul routes were assumed as shown in Exhibit 18. Two of the routes ran north from Illinois Avenue to beyond Harry Hines Boulevard, one on Westmoreland Road and

EXHIBIT 18

MAP OF TAXI POOL ROUTES



Mockingbird Lane and the other on Inwood Road and Cedar Springs Road. Both of these line haul routes were approximately 8 miles in length. The third route ran north from Kiest Boulevard on south R. L. Thornton Freeway toward downtown, then northwest on Stemmons Freeway and Carpenter Freeway to Walton Walker Boulevard. This route was approximately 13 miles long. It was assumed that approximately 2 miles of pick-up and delivery travel would take place at either end of the trip. In general, the range of possible trip lengths in the prototype area was estimated to be 5 to 20 miles.

The taxi pool concept was analyzed by comparing it with other modes of transportation. A total of four possible modes were investigated:
were:

- private van pools carrying 12 persons
- private autos carrying 1.4 persons
- taxi pools carrying 5 passengers
- taxi van pools carrying 11 passengers

The basic data for these four modes is shown in Exhibit 19.

The cost of each of the four modes of transportation was estimated for each of 10, 20, 30, and 40 mile round-trips, which encompasses the range of trip lengths which might be experienced in the study area. The taxi pool and taxi van pool costs included the costs for five extra miles of access time per round trip, which took into account costs incurred by the taxi company in getting to the taxi pool route. The price of gasoline was assumed to be $1.00 per gallon.

Assumed fixed and variable costs per day are shown in Exhibit 20. Exhibit 21 sums these into total costs and presents costs per passenger figures for each of the four alternatives and four trip lengths. Exhibit 22 shows the total and per passenger fuel consumption in gallons.

The following conclusions were drawn concerning the taxi pool concept based on the data presented in Exhibits 21 and 22:

EXHIBIT 19

TAXI-POOL BASE DATA

	Private Vanpool	Private Car	Taxi	Taxi Vanpool
Fixed Costs				
Annual capital cost	3,290 [d]	1,240 [a]	4,290 [b]	3,290 [d]
Annual taxes	60 [c]	60 [c]	60 [c]	60 [c]
Annual insurance	600 [c]	500 [a]	4.3	4.3
	3,950	1,350	4,350	3,350
Variable Costs/Mile				
Serv. & Maint.	2.0¢ [c]	4.8¢ [a]	9.0¢ [b]	9.0¢ [b]
Tires	.6¢ [c]	.6¢ [a]	.6¢ [b]	.6¢ [b]
Insurance	—	—	4.3¢ [b]	4.3¢ [b]
Admin.	—	—	7.5¢ [b]	7.5¢ [b]
Labor	—	—	40.0 [b]	40.0 [b]
	2.6¢	5.4¢	61.4¢	61.4¢
Gasoline	10mpg [c]	16mpg [a]	14mpg [b]	10mpg [c]
$1/gallon	10¢/mi	6.25¢/mi	7.14¢/mi	10¢/mi
$1.50/gallon	15¢/mi	9.375¢/mi	10.7¢/mi	15¢/mi

Assumptions:

Capital costs:

Private vanpool: $10,000, 100% financed, at 14% over 4 years
Taxi: $7,300, 100% financed, at 16% over 2 years
Taxi vanpool: use private vanpool estimate
Private car: AAA estimates

Salvage value of the van is not included; it will serve to reduce capital costs on the next van purchased.

Sources:

a AAA "Your Driving Costs"
b Dallas taxi companies
c Texas Governor's Office of Energy Resources Vanpool Implementation Handbook
d Computed
e Inflated FHWA 1976 "Cost of Owning & Operating An Automobile" data for this category

EXHIBIT 20

TAXI-POOL FIXED AND VARIABLE COSTS

Variable Costs Per Day	Private Vanpool	Private Car	Taxi	Taxi Vanpool
10 mile round trip	.26	.54	6.14	6.14
Gas @ $1/gallon	1.00	.63	.71	1.00
Empty time (5 mi.)	—	—	3.43	3.57
	1.26	1.17	10.28	10.71
Per passenger	.105	.84	2.06	.97
20 mile round trip	.52	1.08	12.28	12.28
Gas	2.00	1.25	1.43	2.00
Empty time (5 mi.)	—	—	3.43	3.57
	2.52	2.33	17.14	17.85
Per passenger	.21	1.66	3.43	1.62
30 mile round trip	.78	1.62	18.42	18.42
Gas	3.00	1.88	2.14	3.00
Empty time (5 mi.)	—	—	3.43	3.57
	3.78	3.50	23.99	24.99
Per passenger	.315	2.50	4.80	2.27
40 mile round trip	1.04	2.16	24.56	24.56
Gas	4.00	2.50	2.86	4.00
Empty time (5 mi.)	—	—	3.43	3.57
	5.04	4.66	30.85	32.13
Per passenger	.42	3.33	6.17	2.92

Fixed Costs[a]	Private Vanpool	Private Car[b]	Taxi	Taxi Vanpool[e]
Annual	$3,950		$3,098[c]	$3,350
Per day	$15.19	$1.80	$ 2.38[d]	$12.88
Per passenger per day	$ 1.27	$1.29	$ .48	$ 1.17

a Based on 260 days.

b No capital costs are assigned to the private car work trip; a $1.80 per day parking cost is the only fixed cost.

c $\frac{260}{365}$ x 4350 total annual cost.

d 20% of daily assignable cost of 11.92 (assume 20% of a taxi's time would be spent in this operation.

e Apply total annual van cost to the taxi vanpool, since the van must be bought for this service.

EXHIBIT 21

TAXI-POOL TOTAL COSTS AND COSTS PER PASSENGER

Total Costs Per Day a/	Private Vanpool	Private Car d/	Taxi b/	Taxi Vanpool b/
10 Mile				
Variable	1.26	1.17	10.28	10.71
Fixed c/	15.19	1.80	2.38	12.88
Total	16.45	2.97	12.66	23.59
Per passenger	1.37	2.12	2.53	2.14
20 Mile				
Variable	2.52	2.33	17.14	17.85
Fixed c/	15.19	1.80	2.38	12.88
Total	17.71	4.13	19.52	30.73
Per passenger	1.48	2.95	3.90	2.79
30 Mile				
Variable	3.78	3.50	23.99	24.99
Fixed c/	15.19	1.80	2.38	12.88
Total	18.97	5.30	26.37	37.87
Per passenger	1.58	3.79	5.27	3.44
40 Mile				
Variable	5.04	4.66	30.85	32.13
Fixed c/	15.19	1.80	2.38	12.88
Total	20.23	6.46	33.23	45.01
Per passenger	1.69	4.61	6.17	4.09

a/ Based on 260 days.

b/ Includes 5 miles empty travel.

c/ From Exhibit 20

d/ Includes no capital costs but includes $1.80 per day parking charge.

EXHIBIT 22

TAXI-POOL FUEL COSTS

Fuel Costs

	Private Vanpool	Private Car	Taxi*	Taxi Vanpool*
10 mile round trip	1.00	.625	1.07	1.50
Per passenger	.083	.446	.21	.136
20 mile round trip	2.00	1.25	1.79	2.50
Per passenger	.166	.89	.358	.227
30 mile round trip	3.00	1.875	2.50	3.50
Per passenger	.25	1.34	.50	.318
40 mile round trip	4.00	2.50	3.21	4.50
Per passenger	.33	1.78	.642	.41

* includes 5 miles empty time.

1. Per passenger, private van pools were the least costly and most energy efficient alternative; however, their long start-up time made them not feasible as an energy contingency measure.
2. Taxi van pools were more efficient and cheaper per passenger than either private cars or taxi pools.
3. Unless the taxi operators had the vans available at the onset of a gasoline shortage, e.g., for paratransit activities, the long start-up time required to acquire the vans made taxi van pools not feasible as a contingency measure.
4. Taxi pools were the most expensive per passenger of the four options considered; however, they were significantly more fuel efficient than private automobiles.
5. Taxi pools were easy to implement. The only start-up consideration was operating procedures.

Circulation Taxi Concept

The fifth paratransit concept examined in this study was the circulation taxi. The service provided under this concept would be a local circulation service much like a jitney service. Unlike the previous four paratransit concepts, no specific geographic area was used to develop a prototype service for analysis purposes. Rather, the intent was to identify the general characteristics of a geographic area and/or market for this service which would be feasible in a contingency situation. This analysis used a series of nomographs provided in a paratransit handbook developed by SYSTAN for the Urban Mass Transportation Administration.[7] These nomographs have been tested and found to be more accurate than regression-based approaches.

The analysis required four steps:

1. estimate the system productivity (passengers per vehicle hour)
2. estimate the demand density (passengers per hour per square mile)
3. estimate daily ridership
4. estimate the household density at various levels of car ownership

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[7] SYSTAN, Inc., Paratransit Handbook, Vol. 2, Prepared for the Urban Mass Transportation Administration. Report # UMTA-MA-06-0054-79-2, II. 1979.

To begin the analysis, it was assumed that the revenues from fares would cover 50% of the operating costs of the service. Since information from taxicab operators in the North Central Texas region suggested that such a service would cost on the order of $10.00 per vehicle hour, then the revenue from the service needed to be about $5.00 per vehicle hour. Based on the consultant's review of similar systems elsewhere, the fare of $.75 per person was assumed which implied, therefore, that the productivity of the system had to average 6.4 trips per vehicle hour in order to provide the desired revenue.

In their paratransit handbooks, SYSTAN plotted vehicle productivity as a function of demand density for a large number of paratransit operations, not all of which were taxi operated. SYSTAN also plotted a least squares regression line through these data and indicated "low" and "high" parallel lines to bound the region in which the data point most frequently fell. Since the "low" boundary line was the most conservative one, it and the regression line were used in this study as the "low" and "average" lines.

In an attempt to focus on taxi-operated systems, the taxi operated cases from the graph were further analyzed. A regression line was plotted through these data, and this "taxi only" line was plotted in Exhibit 23. It was apparent that these lines differed little and that neither line explained the data well.

The lines in Exhibit 23 labeled "average," "low," and "taxi only" were all used in the analysis to estimate trip densities. The three estimates were —

- average = 3.5 trips per square mile per hour
- low = 6.8 trips per square mile per hour
- taxi only = 5.7 trips per square mile per hour

Temporarily, it was necessary to assume a service area in order to compute the daily ridership. The assumption was 16 square miles. This assumption was only for computational purposes and was subsequently omitted. Based on this assumption, however, the daily ridership estimates were —

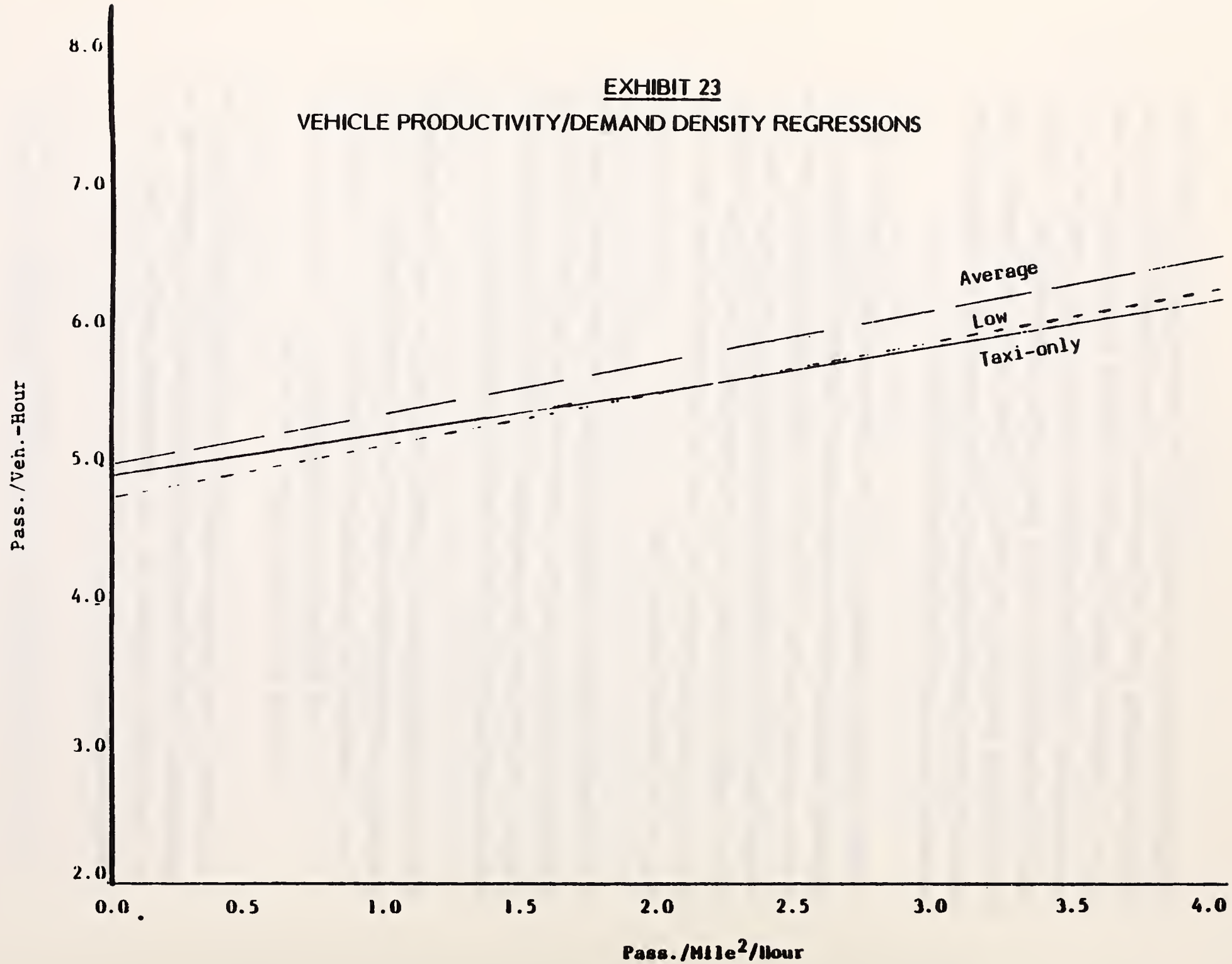


EXHIBIT 23
VEHICLE PRODUCTIVITY/DEMAND DENSITY REGRESSIONS
Average
Low
Taxi-only
Pass./Veh.-Hour
8.0
7.0
6.0
5.0
4.0
3.0
2.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Pass./Mile²/Hour

- average = 672 passengers per day
- low = 1,305 passengers per day
- taxi only = 1,104 passengers per day

From the nomograph, it was possible to work backwards from daily ridership to find the household density for this type of service at various levels of car ownership. Results of this analysis are shown in Exhibit 24. The three curves delineate the feasible combination of household density and household auto ownership. The interpretation of these curves was that the area above and to the right of each curve was the feasible area defined by that curve. Thus, the "low" curve defined a smaller region than the "average" curve.

Also plotted in Exhibit 24 are data points representing three representative areas within the North Central Texas region. These areas were located in White Settlement (zone 478), Brookhollow Industrial District (zone 231), and Oak Lawn (zones 53 and 54). These three areas were used purely for illustrative purposes and represented three very different densities of employment and households. The characteristics of these areas are shown in Exhibit 25.

Note that the areas investigated included a range from heavily populated areas with little employment to areas with mostly employment activity. Thus, it was necessary to provide for employment density as well as household density to analyze the alternatives. To accomplish this, it was assumed that the number of persons per square mile on the average was three times the number of households per square mile, and, thus, for each analysis area, it was possible to calculate an equivalent "employment household" density.

The residential and employment densities must be carefully interpreted. To add these densities would have overestimated the density of an area since people living in an area might have also been employees there. Moreover, part of the residential based demand for circulation taxi services were non-work trips occurring during nonpeak hours. Thus, the two density estimates for each area were considered separately.

EXHIBIT 24

HOUSEHOLD DENSITY NOMOGRAPH

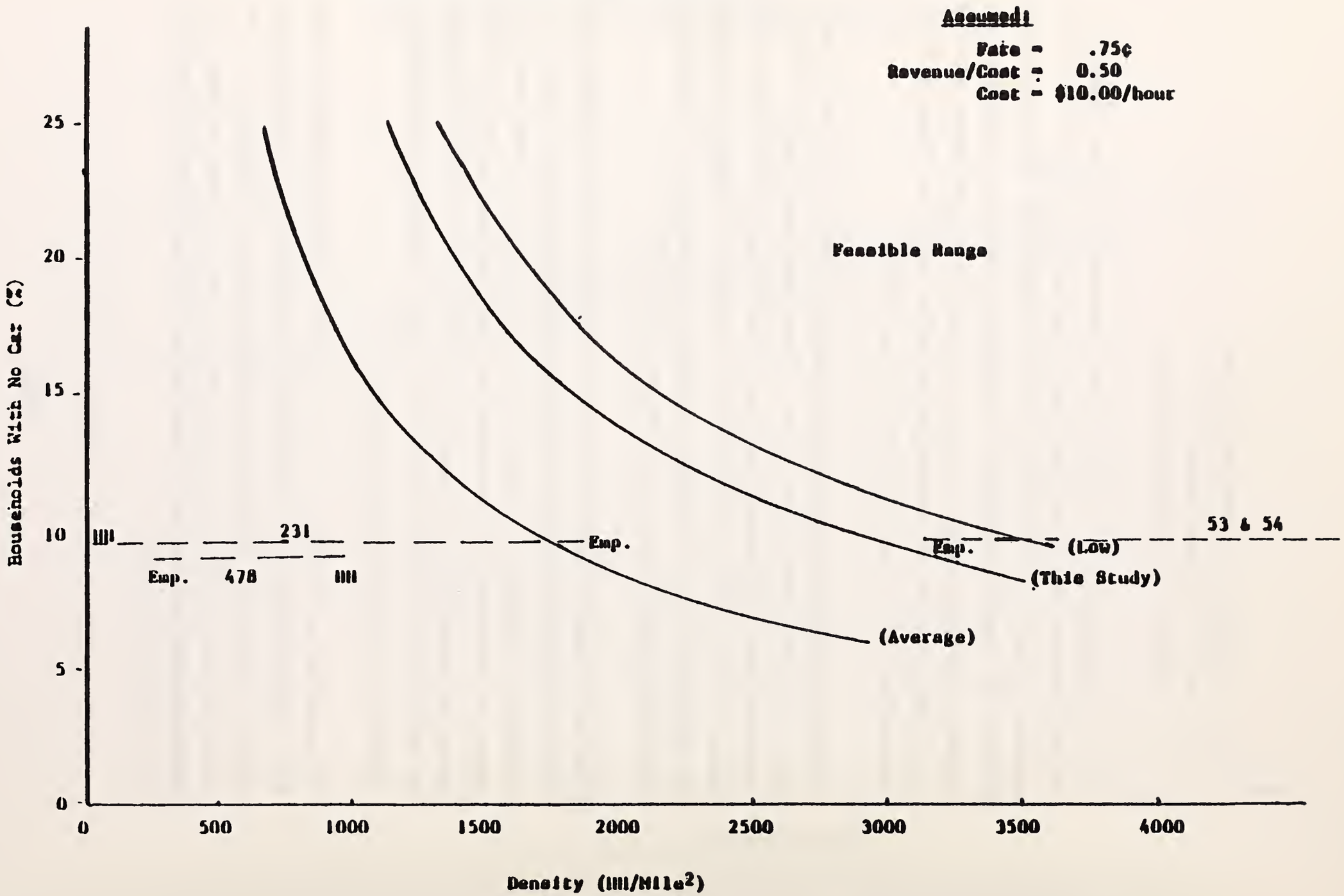


EXHIBIT 25

CHARACTERISTICS OF CIRCULATION-TAXI SUBAREAS

		RAA	
	478	231	53 & 54
Population	14,247	219	15,907
Employment	2,224	18,441	14,555
Households (HH)	4,606	69	8,461
Area (sq. mi.)	5.334	3.2969	1.550
% No Auto	9.09	9.489	9.489
HH/sq. mi.	864	21	5,459
Jobs/sq. mi.	417	5,593	9,390

The differences in the three curves in Exhibit 24 suggested that the analysis might be very sensitive to the assumptions used. To test the sensitivity of the methodology, the analysis was repeated using various combinations of the input assumptions. An example of this is shown in Exhibit 26. All three curves in Exhibit 26 utilized the "low" productivity curve; however, the cost per vehicle hour, fare, and subsidy levels were varied. The rather large differences among these curves suggested that the methodology was indeed highly sensitive to the input assumptions.

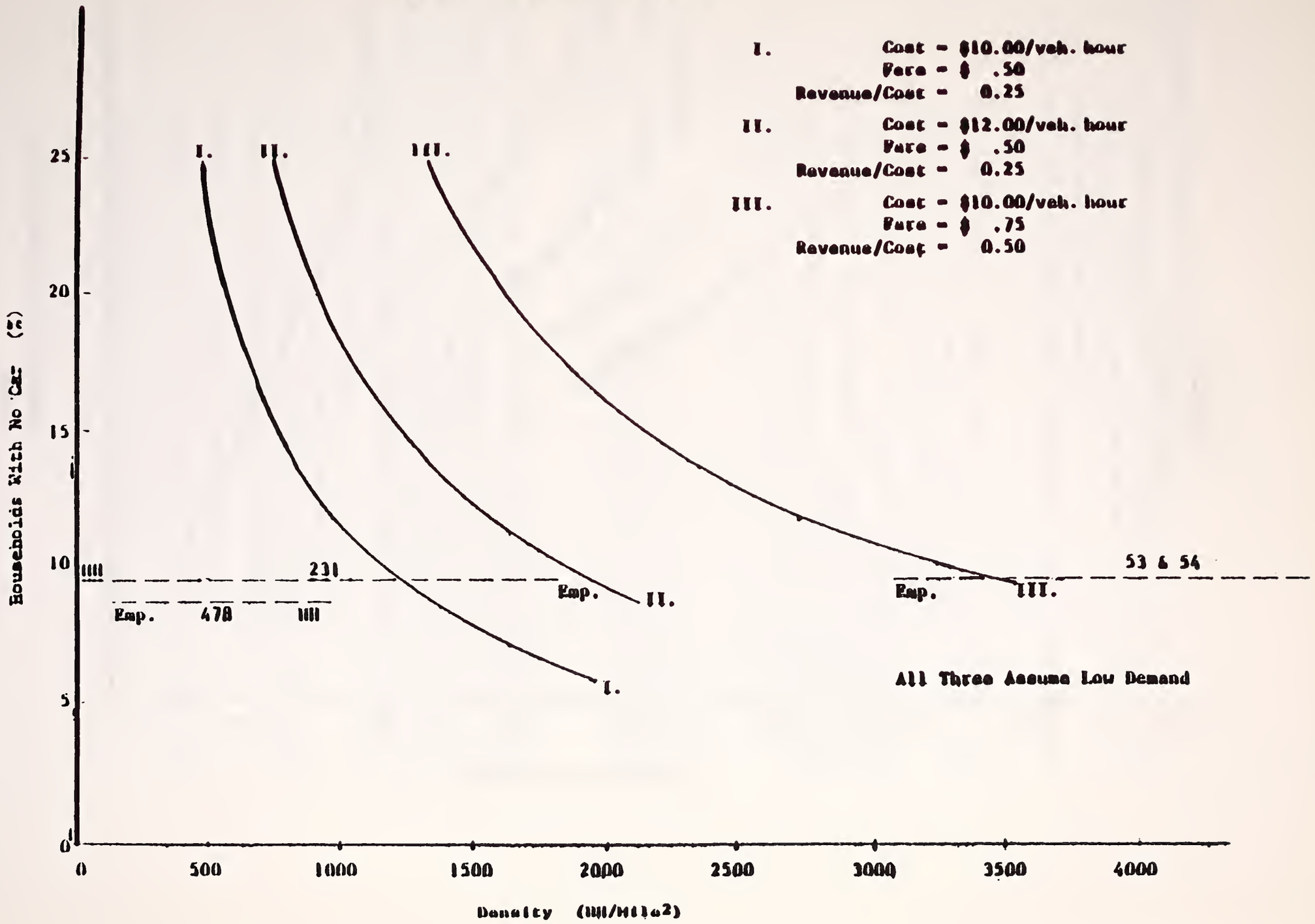
The paratransit systems documented in the SYSTAN paratransit handbook were checked to see if any resembled possible systems in the North Central Texas region. However, little similarity was found between the North Central Texas region and any consistent pattern of operational characteristics of those examples presented in the SYSTAN survey.

To analyze the energy consumption of the circulation taxi concept, it was assumed that the circulation taxi vehicle would achieve a fuel efficiency of 10 miles per gallon and that the productivity of the system would range from 0.5 passenger miles per vehicle mile to 2.0 passenger miles per vehicle mile. For the private automobile, the miles per gallon was allowed to vary from 15 to 30 and the passengers per vehicle from 1 to 3. The results are shown in Exhibit 27. It is clear that, under these assumptions, the circulation taxi is more energy intensive than a private automobile.

The above analysis indicated that the circulation taxi was feasible for some areas within the North Central Texas region. For example, in areas with density above 1,700 households (residential or employment per square mile) and approximately 9 to 10% of households with no car, the average demand curve indicated that the circulation taxi with at least 6.67 passengers per vehicle hour was feasible.

EXHIBIT 26

DENSITY/SENSITIVITY ANALYSIS



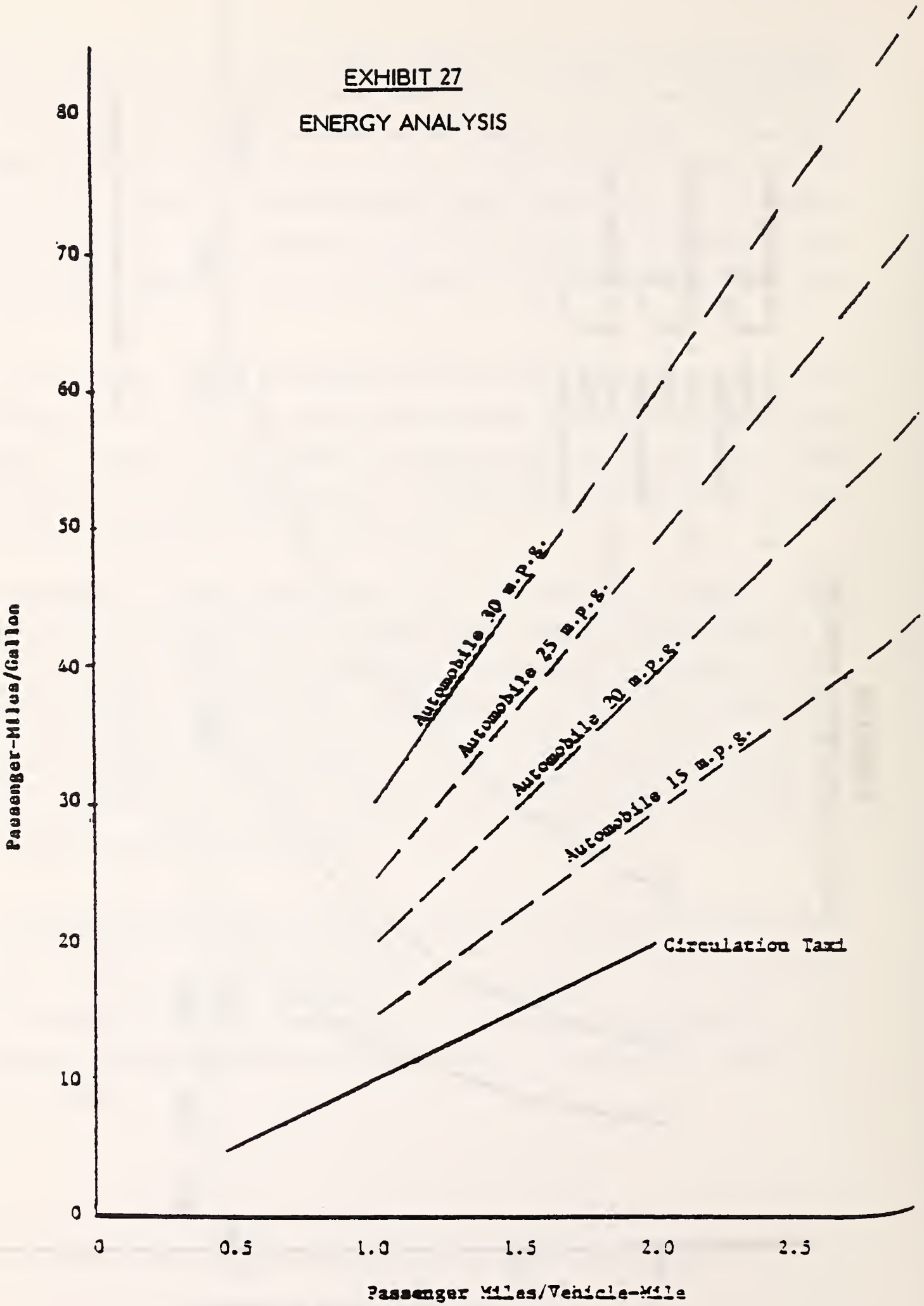


EXHIBIT 27
ENERGY ANALYSIS
Passenger-Miles/Gallon
80
70
60
50
40
30
20
10
0
Automobile 30 m.p.g.
Automobile 25 m.p.g.
Automobile 20 m.p.g.
Automobile 15 m.p.g.
Circulation Taxi
0
0.5
1.0
1.5
2.0
2.5
Passenger Miles/Vehicle-Mile

The analysis led, therefore, to four conclusions:

1. A feasible geographic area for circulation taxis was an area containing over 1,700 households per square mile and 9% or greater proportion of autoless households.
2. The taxi circulation option was generally less efficient than an automobile.
3. If implemented, this option should attempt to use smaller, more energy-efficient taxi vehicles in order to make them more competitive with the automobile as far as fuel use.
4. Overall, the circulation taxi concept did not have demonstrable benefits from an energy standpoint. It could provide mobility during times of acute energy shortages, but this mobility would have been associated with a rather high energy cost, and therefore was a relatively unattractive option.

Implementation

Overall it appeared that the best options were route taxis, transit taxis, and feeder taxis. The worst option was the circulation taxi, while the taxi pool concept fell in mid-range.

Each of the five services, however, entailed several design decisions because each design concept could be implemented in more than one way. Thus, there were many decisions to be made for each service concept. However, six general implementation steps were necessary for all of the concepts:

1. Defining implementation criteria which would provide a "trigger" for the service to be implemented.
2. Designing each service with specific service levels.
3. Delineating management responsibilities with respect to the taxicab operator, transit system, employer, city government, etc.
4. Executing contracts between the parties involved.
5. Preparing marketing and public relations materials to inform the public of the availability of any new services.
6. Developing procedures for the termination of such services.

In addition to these general implementation steps, some specific actions were recommended to implement these contingency paratransit services in the region. These actions were—

1. Revising taxicab ordinances to specifically allow shared-ride taxicab services. A model set of city ordinances would be one way to assist in this effort.
2. Analyzing specific service areas for the different types of services and identifying specific service areas prior to the need for any emergency services.
3. Executing service contracts on an entrepreneurial basis with regard to taxicab operators. Model contracts would again be a useful undertaking in this regard.
4. Preparing public information materials in advance outlining the services to be provided.

INSTITUTIONAL CONSIDERATIONS

The study recommended that the following institutional items should be considered in the planning of paratransit contingency services:

Competition Between Operators

Private transportation providers viewed themselves in competition with one another, as well as with public transportation agencies. Likewise, public agencies also saw themselves in competition with private operators. While it appeared possible to promote a cooperative spirit in energy contingencies because the potential for additional patronage existed for all operators, there could be occasions when competition presented a problem. In particular, this arose in collecting the cost information for operations. It was necessary to assure certain operators that individual company data would not appear in any published reports and that individual data would be kept confidential.

Transit Control

In instances where taxicab operations were considered in concert with normal transit operations, concerns were expressed as to how the two modes should

operate for the benefit of both. In such circumstances, it was recommended to designate one mode as the prime mode and therefore responsible for the operation of the entire multimodal system. It emerged from this study that the transit operator should be designated the prime mode and that the taxicab operator should contract with the transit agency. This would make the taxicab operator directly responsible to the transit agency for operations.

Assurance of Service During Contingencies

One of the most difficult problems to overcome is the assurance that the taxicab operators would indeed provide the service as promised during fuel shortages. The experience (documented in the NCTCOG regional plan) of the Houston area during a transit strike gave evidence that taxicab drivers might not be willing to participate in a organized scheme for providing transportation. The taxicab firm owners in the Dallas-Fort Worth area also raised this as a concern. In particular, with so many of the taxicab companies going to independent owner-driver set-ups, wherein each individual taxicab driver is a private business person and is not, in any way, required to operate his business according to the umbrella taxicab company, it is extremely difficult to assure that taxicab services contracted in advance, would actually be provided during an energy shortage.

Regional Energy Cost Impacts

For the purposes of studying the energy cost impacts on the taxicab industry, Dallas-Fort Worth taxicab companies were categorized as large (50 cabs or more) or small (less than 50 cabs). This was deemed necessary due to the significant differences found in the operating characteristics of the large taxicab companies versus those of the smaller companies.

To conduct the analysis of the impact of higher gasoline prices, prices effective as of July 1979 in the Dallas-Fort Worth area were compared to prices of comparable types of gasoline in July 1978. These data are presented in Exhibit 28. It can be seen that the price increases during this one-year time frame ranged from 38% for premium leaded gasoline to 45% for leaded regular.

EXHIBIT 28

DALLAS-FORT WORTH RETAIL GASOLINE PRICE INCREASES
July 1978 to July 1979

Types of Gasoline	July 1978 (Cents)	July 1979 (Cents)	Increase (Cents)	Percent Change
All Types	60.2	85.9	25.7	43%
Leaded Regular	57.9	83.8	25.9	45%
Unleaded Regular	61.6	88.0	26.4	43%
Premium	64.3	89.0	24.7	38%

SOURCE: Bureau of Labor Statistics, Gasoline Index Specialist

The actual average gasoline price increases experienced by large and small taxicab operators is shown in Exhibit 29. The average taxicab operator affiliated with a large taxicab company which purchased gasoline on a wholesale basis experienced a 29¢ increase in the per gallon cost of gasoline, or a 54% increase, between July 1978 and July 1979. On a per cab basis, this translated into a $1,100 annual increase in operating costs attributable to gasoline expenses alone. Similarly, the operator affiliated with a small taxicab company where gasoline was purchased on the retail market experienced a 24¢ increase (41%) during the same period. This increase translated into a $1,350 annual cost increase per taxicab. While the annual increase in gasoline was lower for the taxicab drivers associated with the smaller companies than for those associated with a larger company, the small company drivers' total cost per cab was higher because they traveled more miles and paid a higher retail price for gasoline.

Exhibit 30 presents operating statistics for small and large taxicab companies for 1978 and estimates for 1979. The data indicate that a cab driver affiliated with a smaller company tended to travel more miles per year, had more paid miles and more passengers, and also used more fuel than larger cab companies.

Exhibit 31 shows the fuel consumption indicators for the taxicab companies in the Dallas-Fort Worth area. Smaller cab companies tended to be less energy efficient than larger cab companies. The smaller companies had fewer total miles, paid miles, and passengers per gallon of gas than the larger companies. Consequently, their fuel costs in all areas were slightly higher than the cost for drivers affiliated with larger companies.

In order to analyze the increased cost of gasoline in terms of the percentage of total operating expenses, it was necessary to collect data from individual taxicab companies. These data are shown in Exhibit 32 and are summarized for all taxicab operations. It was necessary to aggregate these data since these operating statistics were not available from all cab companies. Note that the cost of insurance was the only expense that increased more rapidly than fuel between 1978 and 1979. The table shows that the total cost of operating a

EXHIBIT 29

FUEL COST IMPACT ON TAXICAB OPERATORS IN THE DALLAS-FORT WORTH AREA

	Operators Affiliated With Large Companies 1/	Operators Affiliated With Small Companies 2/
Average miles/cab/year	40,000	50,000
Average increase in price of gasoline July 1978-July 1979	$.29	$.24
Average miles per gallon	10.1	8.0
Average increase in per mile cost of operating a cab caused by fuel price increase	$.029	$.027
Average annual operating cost increase per cab due to fuel increase	$1,160.00	$1,350.00

1/ Data reflect averages of information obtained from large taxicab companies in the Dallas/Ft. Worth area.

2/ Data reflect averages of information obtained from small taxicab companies in the Dallas/Ft. Worth area.

EXHIBIT 30

AGGREGATE TAXICAB OPERATING STATISTICS FOR DALLAS-FORT WORTH AREA 1978 and 1979

Operating Statistics	Large Companies 1978	Large Companies 1979(est.)	Small Companies 1978	Small Companies 1979(est.)
Total Miles/Cab	37,264	31,422	48,572	59,838
Paid Miles/Cab	16,445	14,511	20,238	24,650
Passengers/Cab	4,205	3,738	5,250	7,893
Gallons/Cab	3,669	3,051	5,903	6,924
Paid Miles/Total Miles	.44	.46	.42	.41

Operating Statistics	Large Companies July 1978	Large Companies July 1979	Small Companies July 1978	Small Companies July 1979
Total Miles/Cab	2,944	2,382	4,124	4,929
Paid Miles/Cab	1,321	1,107	1,641	1,949
Passengers/Cab	291	284	422	510
Gallons/Cab	278	233	492	544
Paid Miles/Total Miles	.45	.46	.40	.40

SOURCE: Taxicab operators in the Dallas/Ft. Worth area.

EXHIBIT 31

AGGREGATE FUEL CONSUMPTION INDICATORS FOR TAXICAB COMPANIES IN THE DALLAS-FORT WORTH AREA

	Large Companies		Small Companies	
	1978	1979(est.)	1978	1979(est.)
Total Miles/Gallon	10.1	10.2	8.0	8.3
Paid Miles/Gallon	4.5	4.8	3.4	3.5
Passengers/Gallon	1.1	1.2	.87	.86
Fuel Cost/Gallon	$.538	$.76	$.54	$.77
Fuel Cost/Total Mile	$.06	$.08	$.07	$.10
Fuel Cost/Paid Mile	$.12	$.16	$.16	$.22
Fuel Cost/Passenger	$.49	$.64	$.64	$.92

	Large Companies		Small Companies	
	July 1978	July 1979	July 1978	July 1979
Total Miles/Gallon	10.7	10.2	8.2	8.8
Paid Miles/Gallon	4.8	4.8	3.3	3.5
Passengers/Gallon	1.3	1.3	.83	.90
Fuel Cost/Gallon	$.526	$.811	$.58	$.82
Fuel Cost/Total Mile	$.05	$.08	$.08	$.10
Fuel Cost/Paid Mile	$.11	$.17	$.17	$.24
Fuel Cost/Passenger	$.46	$.68	$.70	$.94

SOURCE: Taxicab operators in the Dallas/Ft. Worth area.

EXHIBIT 32

AVERAGE TAXICAB OPERATING EXPENSES IN DALLAS-FORT WORTH AREA

	Cost Per Mile (¢/Mile)				
	1978	% of Total	1979	% of Total	% Change
Labor (drivers)	32.0	.60	40.0	.58	25.0
Vehicle Operation					
Fuel	5.4	.10	8.0	.12	48.1
Tires	0.4	.01	0.5	.01	25.0
Maintenance					
Labor	3.5	.07	4.5	.06	28.6
Parts	3.5	.07	4.5	.06	28.6
Insurance	2.8	.05	4.3	.06	53.6
General Administration	5.5	.10	7.5	.11	36.4
TOTAL	53.1	100.00	69.3	100.00	31.0

taxicab on a per total mile basis rose from 53.1¢ in 1979 to 69.3¢ in 1979, a 31% increase, while fuel increased by 448.1% during this same time period.

The fare structures for the major taxicab companies in the area are contained in Exhibit 33. This data was effective as of May 1979 and did not reflect any rate changes related to the fuel shortage that began in that same month. At the time there were no provisions in the Dallas-Fort Worth area for fuel adjustments for taxicab rates.

The impact on the net income of the taxicab driver of higher gasoline prices was estimated using the following assumptions:

- trip length: 10 miles
- initial meter charge: $1.30
- per mile charge: $.75
- miles per gallon: 9.1
- fuel price (March): $.672/gallon
- fuel price (July): $.859/gallon
- fuel price (January 1980): $1.037/gallon

The technical consultant concluded that the loss of revenue from a ten-mile trip between March 1979 and July 1979 was 20¢, and between March 1979 and January 1980 was 40¢. Since the average driver traveled 3,750 miles per month, the income loss during the four-month period was $300 and for the ten-month period, the loss was $1,500, on the average. Since the owner/operator driving arrangement was the most prevalent in the Dallas-Fort Worth area, these costs were generally borne by the individual taxicab driver.

Methods to Alleviate Cost Impacts

The remainder of this particular areawide analysis was focused on identifying possible ways to reduce the impact of higher gasoline prices on taxicab operations without seriously affecting ridership. Numerous possible actions were identified within three general categories: technological, service, and legislative.

EXHIBIT 33

FARE STRUCTURES

	Dallas (effective March 1979)	Ft. Worth (effective April 1979)	Arlington Grand Prarie (effective 1979)
Initial Meter Charge	$1.30	$1.30	$1.00
Charge per Mile	$ .70	$ .80	$ .80
Traffic delay/ Waiting Time	$8.00 per hr.	$8.00	$9.00
Extra Passenger Charge	$ .50	$ .50	$ .25
Extra Passenger Charge (between 9 p.m. and 8 a.m.)	$1.00 ($3.00 per trip max.)	—	—
Fuel Adjustment Charge	—	—	—

Technological Methods

The technological methods investigated were electric vehicles, more energy-efficient vehicles, fuel storage tanks, and diesel taxicabs.

Electric vehicles were viewed as attractive because they do not rely on petroleum fuels. However, the electric vehicle was found to have a driving range of 20 to 50 miles per charge, and since Dallas-Fort Worth cabs averaged 100 to 150 miles per day, electric taxis could be run less than one half of the day without recharging. Recharging electric vehicles was found to require up to 12 hours, although methods for simply replacing discharged batteries with recharged batteries were under examination. This charging problem, plus the cost at that time of from $12,500 to $15,000 per electric vehicle, made this option infeasible.

More energy-efficient petroleum-powered vehicles were considered. For example, the Volkswagen Rabbit has proven to be an efficient taxicab vehicle. The technical consultant estimated that the 1979 Volkswagen Rabbit, with an estimated fuel mileage of 20 miles per gallons in the city, would need approximately half of the gasoline used by the average regular taxi in normal operation. Such fuel efficient vehicles would not, however, be effective as an energy contingency strategy because of the time required to replace the current fleet.

Use of fuel storage tanks as a strategy to combat energy shortages was examined by the technical consultant. Two benefits were seen in this strategy. First, the storage of fuel allowed the price of fuel to be hedged somewhat because the companies could buy fuel in advance of actual need. The other benefit was the ability to avoid retail gasoline stations and their inevitable queues during an energy shortage. Of course with only one central pump, it would be a disadvantage to cab drivers in the larger areas who must return to this central pump to refill rather than obtaining fuel at the closest service station.

The consultant suggested that the storage of fuel could be implemented in any one of three ways:

1. each taxicab company could obtain its own fuel tanks
2. the companies could form a cooperative
3. the city or cities could purchase tanks or allow the taxicab operators to share in the public transit tanks in a contingency

The consultant suggested, for example, that the expanded fuel storage at Dallas Transit and CITRAN recommended by the regional energy contingency plan could be shared with taxicab companies.

The cost of acquiring and installing a 12,000 gallon tank with one pump would be approximately $12,000. In addition, at the fuel prices at that time it would cost another $12,000 to $15,000 in fuel to fill the tank.

The final technological solution identified was the diesel taxicab. A diesel taxi demonstration project in New York City in 1976-78 found that diesel taxis got almost 50% more miles per gallon than comparable gasoline powered taxis and that pollution levels were substantially lower from these diesel automobiles.[8] At the time of the study, very few automobiles appropriate for taxi service in the United States were available with diesel engines, and the Oldsmobile was the only American-made diesel automobile available. The consultant noted, however, that Checker expected to produce a diesel taxicab with the same engine as that available in the Oldsmobile by the mid-1980s. Checker quoted a price of $9,952 for a cab with a 350 cubic inch diesel engine. A comparable Checker cab with a V-6 gasoline engine then had a base price of $7,597.

Although there would be some disadvantages to diesel engines for taxicabs (most notably taxicab mechanics' unfamiliarity with diesel engines,the difficulty of obtaining parts, and the more limited availability of fuel), the higher cost of

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[8] Karl Hergenrother, "The Performance of Diesel Taxicabs in New York City Taxicab Fleets" in Productivity Improvement for Taxi/Paratransit Industry. Carnegie-Mellon University. 1978.

a diesel cab would be more than made up by the fuel cost savings. The consultant recommended that area taxicab firms pay close attention to the experiences of taxicab companies that adopted the Checker diesel when it became available and should seriously consider using such vehicles. (Note: Checker has gone out of business since the original research was done. Other automobile manufacturers are increasingly offering diesel utilities, however.)

Service Methods

Three service methods were identified which would increase taxicab productivity in order to reduce fuel consumption. They were —

- increased shared-ride/jitney services
- increased utilization
- increased feeder service to transit

In terms of productivity, shared-ride service has been proven effective. The national average for exclusive-ride was found to be approximately three passengers per taxi-hour, according to the International Taxicab Association. The shared-ride services operating in cities across the country have increased the passengers per taxi hour to four in Davenport, Iowa, and to six in Little Rock, Arkansas, and Red Bank, New Jersey. A computer system has been used in Davenport for dispatching shared rides. This system, while limited in capacity, has improved productivity by more than 50%.

The mini-computers used for dispatching cost approximately $50,000 for a fleet of 50 taxis and $100,000 for a fleet of 100. A study done in 1978 indicated that, for paratransit systems above 32 vehicles, automation of the dispatching function was effective.[9] Another study concluded that a shared route-taxi fleet of 50 vehicles could cost-effectively utilize automated dispatching.[10]

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[9] Multisystems, Inc., Benefit-Cost Analysis of Integrated Paratransit Systems, Volume 5. May 1978.

[10] U.S. Department of Transportation. The Shared-Ride Taxi System Requirements Study. May 1979.

As far as increased utilization, the consultant noted that in 1979, more than 50% of the taxi miles traveled in the Dallas-Fort Worth area were not paid miles. Methods for increasing utilization were considered essentially cost-free and easy to implement. Suggested methods included limiting cruising, requiring the operators to stop and wait for calls rather than returning to taxicab stands, and also increasing the number of taxicab stands throughout the city.

The consultant noted that taxicab companies could educate the drivers on techniques to reduce unpaid miles. It was also pointed out that the "bid" system for dispatching used in Dallas was not energy or cost efficient. Since drivers could underbid one another under this system, the closest driver to the call, and thus the one who could most efficiently pick up the rider, would not necessarily be sent to the call.

The consultant noted that taxicabs could provide feeder services to transit lines during an energy shortage on a shared-ride basis. If this service were provided, it would probably increase the overall paid-miles per passenger.

Legislative Methods

Three legislative approaches to reducing the impacts on the taxicab industry were analyzed. These were --

- exempt taxis from pollution law restrictions
- exempt taxis from gas taxes
- provide fuel escalation clauses and/or surcharges in rate structure

The consultant found interest among the taxicab operators in exempting taxis from the pollution law restrictions. Technical analysis showed, however, that pollution control equipment in 1975 and later model cars in fact had very little impact on fuel efficiency. Although pollution equipment installed prior to 1975 did result in a 10% to 20% reduction in fuel efficiency, catalytic converters and accompanying technology used since 1975 had a much smaller effect on fuel consumption. On 1979 and 1980 models, for example, pollution control equipment reduced fuel efficiency by less than 1%. Thus, it appeared that making this change would probably not be worth the trouble.

To help ease the cost of fuel on the taxicab operator, it was suggested that taxicabs be exempted from the state tax on gasoline. At the time of the study, the Texas state fuel tax was 5¢ per gallon. Assuming 40,000 miles per year and a 10 mile per gallon fuel efficiency, removal of the gas tax would save the taxicab operator approximately $200 per year. This would constitute less than a 5% decrease in the cost of fuel. Thus, this measure was not deemed particularly effective, especially since automobile fuel economy was expected to increase significantly in the future and thus the savings from eliminating a small per-gallon gasoline tax would be minimal.

As noted earlier, there were no provisions in local taxicab rates at the time of the study for countering the increased costs of operating a taxicab vehicle. A fuel surcharge that would increase at specific points as the price of fuel increased was suggested. New York City taxicabs, for example, have had authority to charge a flat 15¢ surcharge per ride to negate some of the impact of higher gasoline prices. A more sophisticated approach could be established to fix fuel prices at which a fuel surcharge would be levied.

Exhibit 34 shows a qualitative assessment of the costs and benefits of the ten methods of alleviating higher fuel costs. This table suggests that the highest benefit-to-cost ratios can be found in increasing the shared-ride or providing jitney service, increasing the productivity or utilization of the taxicab services, and providing escalation clauses in fare structures to account for higher fuel prices.

IMPLEMENTATION OUTLOOK

While the concepts analyzed here were generally feasible, the following barriers to implementation still exist:

1. In the event of an energy shortage, the transit operator could take the lead in organizing the integrated service with taxicabs. However, at such a time, the transit operator would probably be so concerned with his or her own operation that getting involved with taxicabs at that time would be unlikely.

EXHIBIT 34

METHODS FOR ALLEVIATING IMPACTS OF HIGHER FUEL COSTS

	Cost	Benefit
TECHNOLOGICAL		
• Electric vehicles	high	medium
• Energy efficient vehicles	medium	high
• Fuel storage tanks	high	medium
• Diesel taxicabs	medium	high
SERVICE		
• Increased shared miles/jitneys	low	high
• Increased utilization	low	high
• Increased feeder service	low	medium
LEGISLATIVE		
• Pollution exemptions	medium	high
• Gas tax exemptions	medium	high
• Escalation clauses	low	high

2. The taxicab operator, on the other hand, could take the leadership in implementing such services. The key here appeared to be profitability. Could these services be shown to be money-making opportunities for the taxicab industry? In particular, if these services did have profit potential, could this be convincingly demonstrated to the individual owner-driver?
3. The operation of emergency taxicab services during a gasoline shortage would require that gasoline be available to the taxicab operator. Additional fuel storage or fuel use agreements appeared to be necessary, but the question remained as to whether it made "good business sense" to make such arrangements.
4. There is a natural reluctance for individuals, businesses, and organizations to prepare for contingencies. Paratransit is no exception. The problem is compounded by the more decentralized nature of paratransit ownership and operations.

In conclusion, it appeared that energy contingency paratransit operations, while feasible and desirable, must be good business for the individual owner-driver before any implementation could be expected. Even today, there is no evidence that this is the case.

V. COMMUNITY TRANSIT ALTERNATIVES

OVERVIEW OF STUDY

Previous NCTCOG work had shown that the school bus offered good potential for providing alternative transportation services during a fuel shortage. This was particularly true in suburban areas where no transit service existed. The work to date, however, had been of a sketch planning nature, and it was time to address the specifics of how school buses could be used. In particular, difficult institutional issues had to be resolved in order to make school bus use a viable option.

It was decided to take a case study approach, i.e., to select a particular suburban community and develop a specific transportation contingency plan for school buses in that community. A specific system proposal, it was felt, would bring into focus those institutional obstacles which would have to be overcome for the plan to become reality.

The City of Arlington was selected as the case study site. Arlington is located midway between Dallas and Fort Worth and is the third largest city in the area (after Dallas and Fort Worth) with a population at that time of approximately 160,000 people. There was no local bus service in Arlington, and it was believed to be the largest city in the United States without local bus service. The City had been working on a transit plan and the University of Texas at Arlington (UTA) had also been investigating transit alternatives as a means of relieving its parking problems.

The key to performing the study was the participation of all major institutions, most particularly the Arlington Independent School District (AISD) which operated a fleet of 75 buses. For this reason, NCTCOG felt that the study should

offer a potential benefit to all who participated. It could not simply be a study of how the AISD's school buses would be used by others.

A factor influencing the scope of the study was the fact that, at the time the study was initiated (late 1978), the 1973-74 oil embargo was nearly forgotten. There was more interest at the time in reducing costly fuel consumption than there was in contingency planning. (Ironically, before the community bus study was over, the summer gasoline shortage of 1979 would alter the participants' view of the study.)

The objective of the study, therefore, was to develop an integrated "community bus system" which would combine the resources of the city, the university and the school district. This transit system would save energy, would provide for mobility during energy shortages, and would be more cost-effective than the planned individual transportation programs of the three organizations involved.

TECHNICAL EFFORT

A project advisory group consisting of representatives from the Arlington Independent School District, the University of Texas at Arlington, the City of Arlington, and the North Central Texas Council of Governments reviewed proposals and selected a technical consultant to perform and document the technical analysis.[11] The technical consultant was to perform an inventory of Arlington's transportation resources available for energy contingencies, to investigate the institutional, legislative and regulatory constraints affecting the use of these resources, and to develop and analyze alternative transit service designs for a community bus system for energy conservation and contingency purposes.

Resource Inventory

It was found that there were relatively few available resources which could be used to provide transit service in Arlington in response to the energy situation.

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[11] Multisystems, Inc. and Dennis Elliott and Associates, Case Study of Community Transit Alternatives for Energy Shortages, Final Report. Prepared for the North Central Texas Council of Governments, May 1980.

Within the city there were only five potential sources of available vehicles outside of private automobiles and company transportation. These were —

1. School buses owned and operated by the Arlington Independent School District. In June 1979 there were 75 school buses of various sizes, most used for only five hours per day on school days. Usage of these vehicles coincided with peak hour periods of general public transit; therefore, it was difficult to use these vehicles under normal circumstances. Also, institutional problems were likely to be encountered. The barriers to using these vehicles might be reduced in the event of a severe energy emergency.

2. Texas Motor Coaches (TMC) vehicles which provided daily scheduled service to Dallas and Fort Worth. The few vehicles employed in serving Arlington were fully applied during virtually the entire day for inter-city travel. It is unlikely these vehicles could be diverted to intra-city travel, but TMC may serve as a contract carrier for an ongoing transit operation. During an energy emergency, the vehicles owned by TMC are likely to be even more heavily loaded, making their use as part of an energy contingency plan unlikely.

3. City Cab of Arlington and Grand Prairie operated 5 vehicles (out of 15 licenses) at the time this study began. This service was unreliable and did not have sufficient capacity for a major role in transit energy conservation or contingency measures.

4. Several social service agencies owned small vans to serve the needs of their clients. Due to their specialized charters, these agencies were unlikely to be willing to divert vans used for their clients to use by the general public. In addition, the six small vehicles owned were often outside the city limits of Arlington and represented only a limited capacity.

5. Vehicles were also owned by churches and church groups in Arlington. Because these vehicles were spread among many churches, coordinating them into an intra-city service was likely to be extremely difficult.

If no available sources of vehicles could be used, the community had the option to buy its own vehicles or contract with a private provider. It was likely to require a significant amount of time to receive new vehicles in the event of an energy emergency. Any private contractor vehicles were likely to be in great demand in such circumstances.

Legal and Regulatory Constraints

The three major potential contributors to a coordinated community transportation system were each subject to different federal, state, and local laws and regulations, and to their interpretation by agencies at these levels.

Federal

U. S. Department of Transportation (USDOT) regulations and requirements were found to affect any local combined or coordinated transit system. The most important one concerned Section 504 accessibility.

At the time of the study, USDOT funding carried the obligation of the July 1979 final Section 504 accessibility regulation (49 CFR Part 27). One requirement of this regulation was that all new buses purchased by an organization receiving or benefiting from USDOT funds must be accessible to all handicapped persons. This meant, among other things, that new buses must have wheelchair lifts. Further, within three years (or up to ten, if an exception was made) one-half of the peak period bus fleet must be fully accessible. Requirements under energy emergency conditions were not clear; but apparently they would be the same, as there were no provisions for a temporary relaxing of this regulation under such conditions.

The USDOT regulation specifically exempted school buses from this accessibility requirement, but it appeared that this exemption applied only when these buses were used for school-related transportation. The then U. S. Department of Health, Education, and Welfare regulations required full accessibility for all school facilities receiving federal aid. This had not been clearly defined with respect to school buses, however.

State and Local

The City was found to come under Title 28 of the Texas Civil Statutes, which governed cities, towns, and villages and which gave them various authorities and responsibilities with respect to transportation. AISD transportation services were regulated by Title 2 of the Texas Education Code and by the regulations of the Texas Education Agency (TEA). The AISD's budget and operations were also

subject to scrutiny by the local school board and by the local voters. UTA is part of the state university system, so it was governed by Title 3 of the Texas Education Code and by regulations of the state university system.

Title 28, Chapter 10, Article 1118w of the Texas Civil Statutes gave cities and towns the power to form and operate their own transit systems. This included funding aspects: issuing city bonds and accepting federal grants. The Texas Department of Highways and Public Transportation could, if funds were available, provide up to 65% of the "local" share for an UMTA grant. The Dallas-Fort Worth metropolitan area transit authority enabling legislation would allow Arlington to provide its own public transit service if the city elected (by public ballot) to join a regional transit authority.

Title 28, Chapter 13, Article 1175 gave home rule cities the power to regulate the use of its streets (with some exceptions for state highways and roads) and (paragraph 21) "to regulate, license, and fix the charges or fares made by any person owning, operating, or controlling any vehicle of any character used for the carrying of passengers for hire . . . on the public streets and alleys of the city." Arlington had a local ordinance implementing this state-given power and regulating such transportation facilities (Ordinance No. 73-130). Generally, this applied to private transportation companies, which must obtain a franchise from the City Council and pay annual fees to the City. Cities also had some control over the operation of public, state-controlled private, and school bus operations on their streets, but not on state highways in their boundaries.

Private bus companies that operated transit systems across city boundaries were found to be subject to regulation by the Texas Railroad Commission (RRC). They must have received a certificate of convenience and necessity; the service, service area, fares, and other operational aspects were regulated; and they must have submitted various reports and paid fees to the RRC.

The Texas Education Code (Article 16, Subchapter F) and its implementing regulations appeared to present the primary limitations to a coordinated or

combined transit system that included school buses. Any school district receiving state (TEA) financial aid for providing school bus services must have complied with several limiting regulations. Such state aid was considered essential by AISD. Funds would be paid only for eligible students on state-approved routes and only if the school district met all other regulations. School buses must have met TEA specifications (Article 6701d, Section 105). Standees were limited by law (not more than one standee per bus seat - Article 6701d-1) and by an October 1979 TEA regulation that included a revised funding formula with fund reductions for standees.

A 1979 revision to the law (S.B. 1082, 1979) permitted use of school buses for other than school use. This amended a 1978 change to Section 16.204 of the Texas Education Code which allowed only governmental or non-profit agencies to charter buses and then only for elderly and handicapped group use; before that no non-school use was allowed. However, the TEA had interpreted this revision to be limited by several conditions:

1. a valid contract is made and is on file
2. all operating and maintenance costs are covered
3. contract proceeds go into the school district's categorical transportation fund and cannot be used for non-transportation purposes
4. the school district keeps required bus records
5. non-school uses do not interfere with normal school-related services

This last requirement generally meant that non-students cannot be carried on a school bus carrying students to and from school. If a school district had extra buses (more than were needed to meet minimum TEA school busing requirements), they could be used to carry non-students during normal school bus service periods. However, school buses could not be used for non-school purposes when they were needed for school-related trips.

School districts could also contract with public transit agencies (but not private bus companies providing "public transit services") for school bus services. However, if state funds supported this service, the non-interfering, non-mixing

rule applied, the buses must be clearly designated as school buses while being used as such, and the costs of such services must be lower than those of school bus service provided by the school district.

Other

There were other institutional jurisdictions affecting the transportation-related actions of other potentially involved organizations. Private, non-profit organizations providing transportation services were restricted not only by their local governing boards but also often by state or national organizations, and as well by agencies of the federal and/or state governments when they were providing funding.

In addition to all of the potential operating, franchise, and financial regulations to which potential local transportation providers might be subject, they all must comply with certain state, and federal safety and licensing regulations. Vehicles used in Texas must comply with the safety, vehicle and driver license reqirements of Title 116 of the Texas State Code. In addition, some of the Texas Education Agency specifications for school buses differed from federal or state specifications for transit buses. Generally, school bus specifications resulted in buses that were uncomfortable for adults (seat pitch, etc.). Transit buses were generally acceptable for school bus use if clearly marked. With minor modifications, either type of bus could be used for the other service as long as it was provided essentially only within one municipality.

Finally, school buses used by school districts receiving state school funds must "be purchased by and through the State Board of Control" (Title 2, Chapter 21, Subchapter F, Section 21.161 Texas Education Code). This board ensured that specifications and other requirements were met. The school district must have proper local and county approval, funding, and support for its request. This process served to limit the number of "extra" buses available to a school district and non-standard (for school buses) configurations of those buses.

System Alternatives

A total of five alternative transit systems were designed which responded to two different energy scenarios. The first energy scenario reflected the conditions as they existed in September 1979, i.e., fuel readily available at a price of approximately $1.00 per gallon. The second energy scenario consisted of a short-fall of petroleum products amounting to approximately 15% of unconstrained usage. It was assumed that there was no gasoline rationing at this point; however, there was an odd-even purchase plan and a minimum purchase requirement in effect. This scenario is similar to the situation which existed in the Dallas-Fort Worth area between the months of June and July of 1979. Only existing transportation resources could be used in providing the service during an energy shortage, while no such restraint existed under the energy conservation alternative.

Alternative #1

The first transit alternative was called the "Conventional Approach" and consisted of the system which would result if the school district, the university, and the city went on with their current plans for public transportation without regard to integrating the services. This alternative presented a base upon which to compare other alternatives requiring some form of joint action or sacrifice of overall service for the members of the three major groups.

The City of Arlington component of the baseline alternative consisted of the fixed-route transit system, proposed in the Transit Implementation Plan, to supplement the flexible door-to-door service for the elderly and handicapped proposed by the city. The fixed route service plan consisted of five routes operating within the city limits on headways of 30 and 45 minutes during peak periods and one hour off peak. During peak periods, 6 a.m. to 9 a.m. and 3 p.m. to 6 p.m., service would be provided along routes primarily oriented to the great Southwest Industrial Park. In off-peak hours in the midday, there were only four routes proposed, with their primary orientation toward the two major shopping centers (Six Flags Mall and Forum 303). Exhibits 35 and 36 present the coverage of these routes during peak and off-peak periods, respectively. The adult fare

EXHIBIT 35

PEAK TRANSIT COVERAGE
Alternative #1

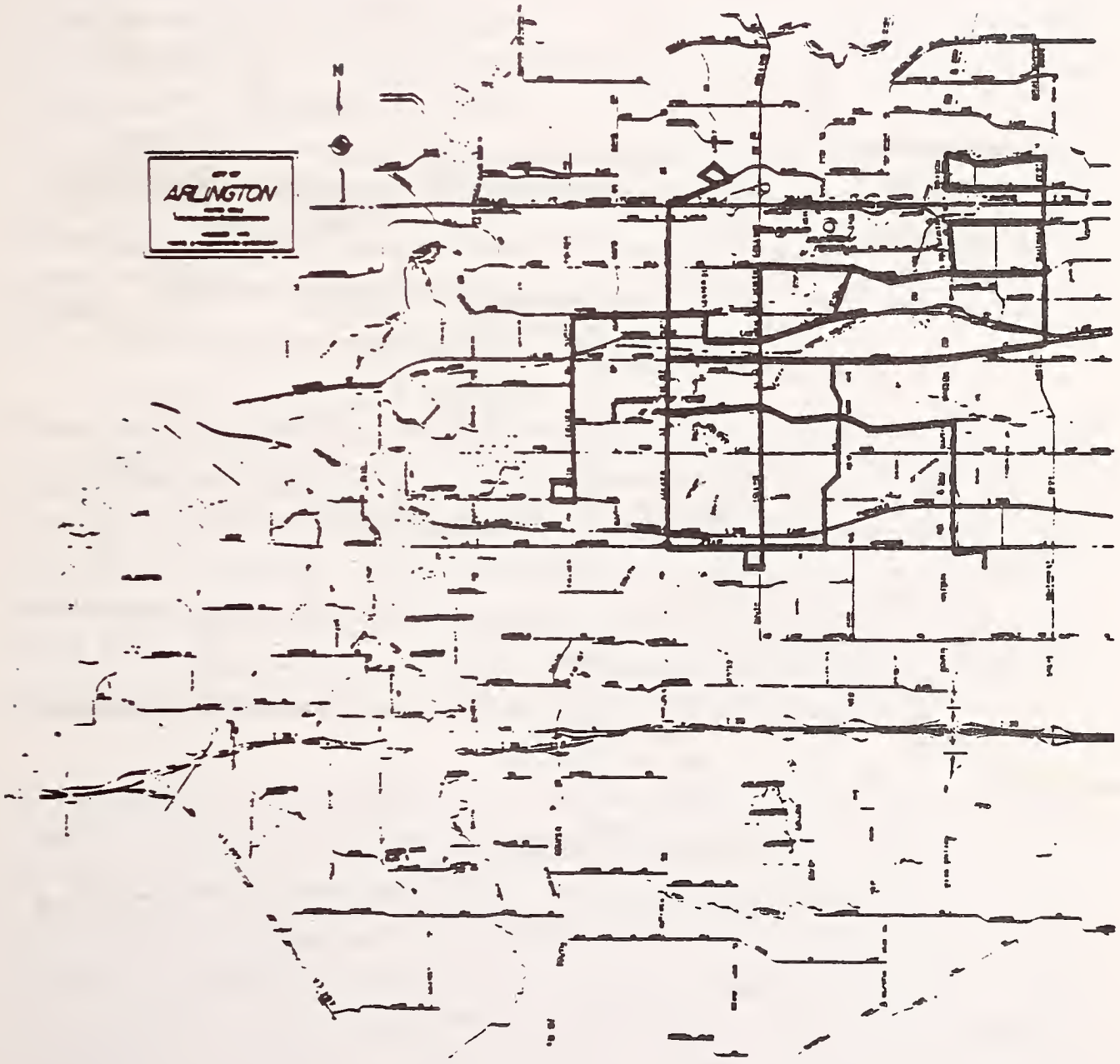
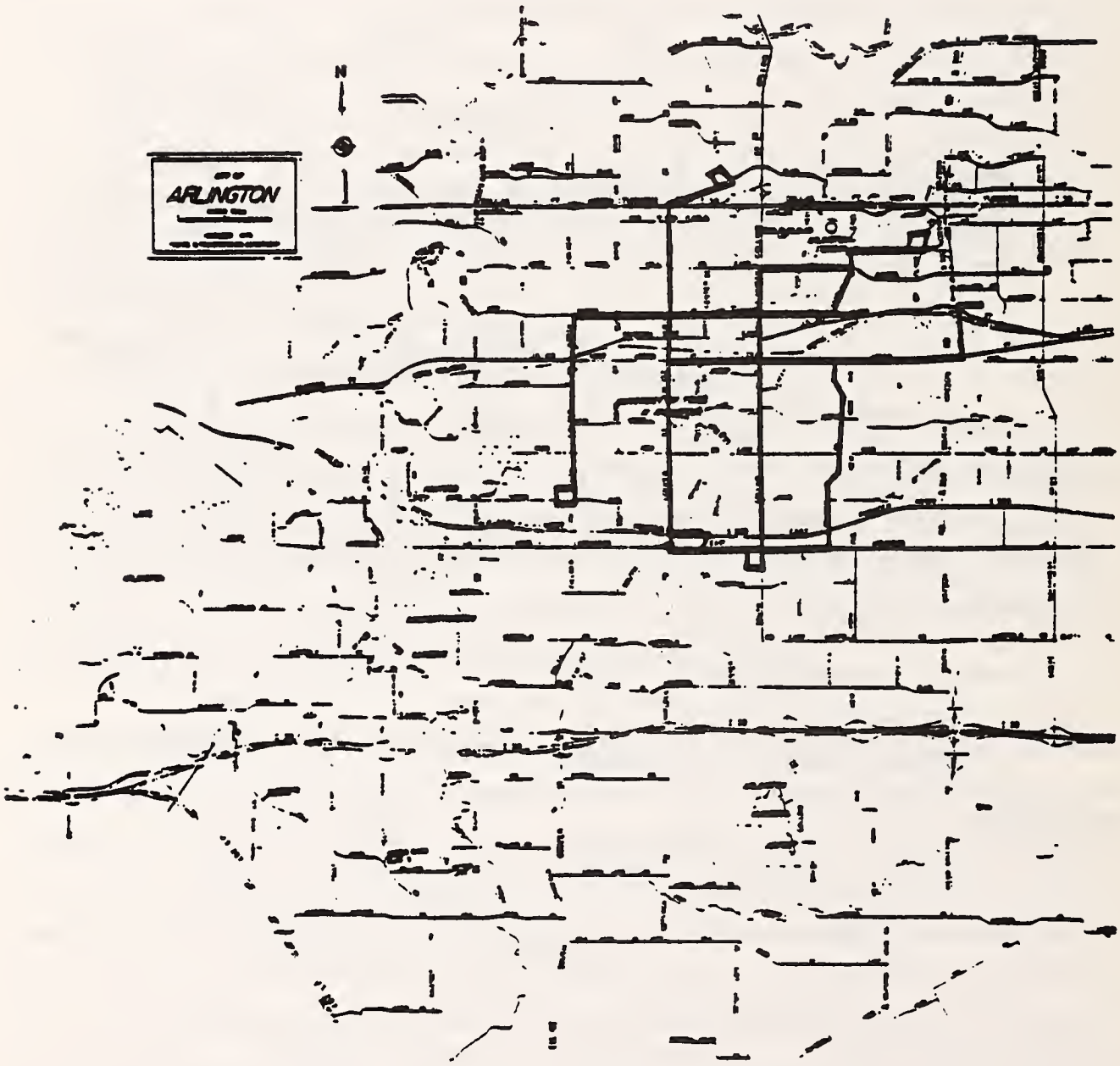


EXHIBIT 36

OFFPEAK TRANSIT COVERAGE
Alternative #1



would be 40¢ with 5¢ transfers while elderly, handicapped, and children would ride for half fare. No evening, weekend, or holiday services are offered.

The Arlington Independent School District portion of the alternative consisted of the same set of routes they ran during April 1979. (Data were not available on more recent routes.) This service consisted of 67 routes, each with between one and three runs during the mornings and evenings. Each day, 4,900 students were carried to school; approximately 40% were elementary school or kindergarten children, 20% went to junior high, and 40% went to high school. Of these students, 200 handicapped students and 450 kindergarten students were transported. Bus stops were located up to three blocks away from students' houses, with the average student required to walk just under 1/12 mile. Students arrived at school in the morning up to one hour prior to the commencement of school. Wait time for the bus after school may have also amounted to a full hour.

The school bus service was managed and operated by the school district itself. Part time drivers and aides were employed at a wage rate of $3.70 per hour. The revenue to operate this service was received from the State of Texas, through a reimbursement formula, and by the local school district through property tax assessments. State reimbursement did not apply for transportation of students living less than two miles from their school. The school district transported approximately 500 of these "ineligible" students using local support.

To facilitate the use of a number of student parking lots far from the major classroom and laboratory buildings of the University of Texas at Arlington, the University planned to provide a shuttle service between some of the most distant lots and the main campus area. Lots to the northwest and the southeast would be connected by a shuttle bus with the center of the campus and several residences on the outskirts of the campus. This service would provide one 20-passenger mini-bus at a frequency of once every 20 minutes. The service would be privately contracted for $1.50/mile. No fare would be charged for use of the service, as revenue is generated through the student activity fee. The shuttle

bus would run five days a week during the school year except holidays (amounting to 216 days per year) between 7 a.m. and 5:30 p.m. The system would be used most heavily during Monday and Wednesday mornings, when the lots have been found filled to capacity. The service would reduce travel time (excluding wait times for the vehicle) from a maximum of eight minutes to only three minutes.

Exhibit 37 presents the results of the analysis of the baseline alternative as compared with a "do nothing" base case. Since the system operated by the school district would be the same in both the existing conditions and this alternative, it was clear that no change would result in the amount of fuel consumed or any other impacts. The other two services would have an impact on fuel consumption by private autos, with the city's fixed route operations and the UTA shuttle resulting in annual savings of 92,744 gallons and 1,534 gallons of fuel, respectively. The majority of the savings resulting from the implementation of the city transit routes were from trips directly diverted from auto driven and auto chauffeured modes. In addition, a smaller reduction (27,419 gallons) was noted as a result of auto ownership characteristics. The UTA service was much less successful. Due to the long headways exhibited by the service, a relatively small portion of the parking lot users were convinced to go directly to the more distant parking lots during peak hours. Their reduction in deadheading saved a total of approximately 2,000 gallons of gasoline per school year. These savings, however, were entirely offset by the 3,477 gallons of fuel expended on operating the service itself.

Other major impacts of the city's fixed route services include mobility, and monetary costs. A relatively large number of trips were taken per day on these services.[12] The breakdown of ridership among the special interest market segments indicated that a good portion of the ridership was from the elderly and no-auto households. Due to availability of special doorstep services for the

[12] The 2387 average weekday ridership identified for this alternative is somewhat lower than that calculated in the TIP. The primary reason for the difference was the methodology employed in the prediction. The chosen method took into account the locations of routes (the number of persons living within walking distance of them) and the service quality (wait time) afforded. It is reassuring that the estimates using the two approaches are as similar as noted.

EXHIBIT 37 (Part 1)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #1: Energy Conservation - Conventional Approach

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)	-1,146.5		+12.8	-1,133.7
private auto	-1,571.9		-13.1	-1,585.0
school bus				
transit	+425.4		+25.9	+451.3
Fuel Consumption (1000 gallons/yr)	-54.0		+1.5	-52.5
private auto (gasoline)	-92.7		-2.0	-94.7
school bus (gasoline)[2]				
school bus (diesel)[2]				
transit (gasoline)			+3.5	+3.5
transit (diesel)	+38.7			+38.7
Monetary Costs ($1000)				
Capital	+65.0			+65.0
Operating	+621.1		+38.9	+660.0
Revenue	+208.1			+208.1
Deficit	+478.0		+38.9	+516.9
Mobility (1000 trips/yr)				
New Transit Trips	+599.1		+115.6	+714.7
Induced Trips	+52.9			+52.9
School Bus Trips[3]				

EXHIBIT 37 (Part 2)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #2: Energy Conservation - Conventional Approach

IMPACTS[1]	INCIDENCE GROUP: CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)	+91.5			+91.5
Temporal Coverage (hours/day)	+12.0		+10.5	+12.0
Safety				
Street Crossings (1000/day)				
primary streets				
secondary streets				
Efficiency & Capacity				
Passengers/Vehicle Hour	26.5	44.7	51.0	40.6
Cost per Passenger ($)	1.15	0.35	0.34	0.54
Deficit/Passenger ($)	0.80	0.17	0.34	0.33
Fuel Saved/Deficit (gal/$)	+0.11	+0.00	-0.04	+0.10
System Capacity (passengers/day)	24,510	6,700	661	31,871

1 All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped unless otherwise noted.

2 Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

3 Includes only home-to-school trips by "eligible students" on school bus or the community transit service.

transportation handicapped, use of fixed routes by this market segment was minimal. A small portion of trips made would not have been made previously. These trips were largely from the small transit captive population.

The costs of the fixed route service, presented under the City of Arlington column, represented the local support of operating deficit and capital equipment. The majority of these costs were put back into the local economy through wages to drivers and maintenance personnel. In addition, if federal subsidy were available,[13] direct employment benefits represented 138% of all local costs.

Exhibit 37 also presents the other benefits resulting from the UTA shuttle service. As might be expected, the service had no impact on diverting students from their automobiles to transit as their primary modes. Some ridership from on-campus housing was achieved, but this was minimal as a result of the generally short walk distances from these apartments and dormitories. No deficit was incurred by the University itself, as student fees support the system. The student fees amount to only $2.01 per student per school year.

Exhibit 37 presents the efficiency indices of passengers per vehicle hour, cost per passenger, deficit per passenger, system capacity, and fuel savings per dollar of subsidy provided at the local level. These figures were useful in comparing the efficiency of various alternatives.

Alternative #2

One potential energy conservation alternative which could have been adopted unilaterally by the Arlington Independent School District was the modification of school bus routes to minimize the vehicle miles traveled. One approach to route modification employed a "neighborhood school transportation center" concept.[14] Under this mechanism, a single transportation center (or bus stop) would be

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[13] 50% of operating deficit and 80% of capital expenditures.

[14] L. C. Cooper, The Use of School Buses for Public Transportation, North Central Texas Council of Governments, Arlington, Texas, 1978.

created for all students living within an area. The size of the area might depend on the street patterns (on other natural barriers), or on constraints on maximum walk distance. The greater the maximum distance, the fewer stops would be required. With fewer stops, average vehicle speeds would increase, and route miles would be diminished. These two factors combined with a practical constraint on routes based on vehicle capacity in determining the amount to which routes would be consolidated.[15]

In accordance with this restriction, transportation centers were placed at locations approximately .75 miles apart as illustrated in Exhibit 38, thereby setting walk distances no higher than one half mile. This configuration provided the greatest coverage with the fewest number of transportation centers. Centers were established only in locations where existing school bus runs pick up students. Where possible, transportation centers were positioned at schools, shopping centers, or other areas away from private homes. All students, except the handicapped students, were required to walk to the nearest transportation center to catch the bus. Handicapped student routes did not change.

The employment of transportation centers reduced the total number of buses required from 67 in the existing conditions to only 51. Each vehicle was required to make between one and three runs, as before; however, the route mileage was significantly reduced. Each run consisted of pickups at between one and five transportation centers. On average, the vehicle made only two and one half stops on the way to school. This fact, combined with the reduced travel on low speed local routes, resulted in much higher average speeds and reduced driver hours. The system continued to operate using the same labor force and administration as under the existing conditions.

Exhibit 39 presents the results of the analysis of the modified school alternative. The major impacts of this alternative noted were the fuel consumed by the school district, fuel used in the transportation of students to school by their

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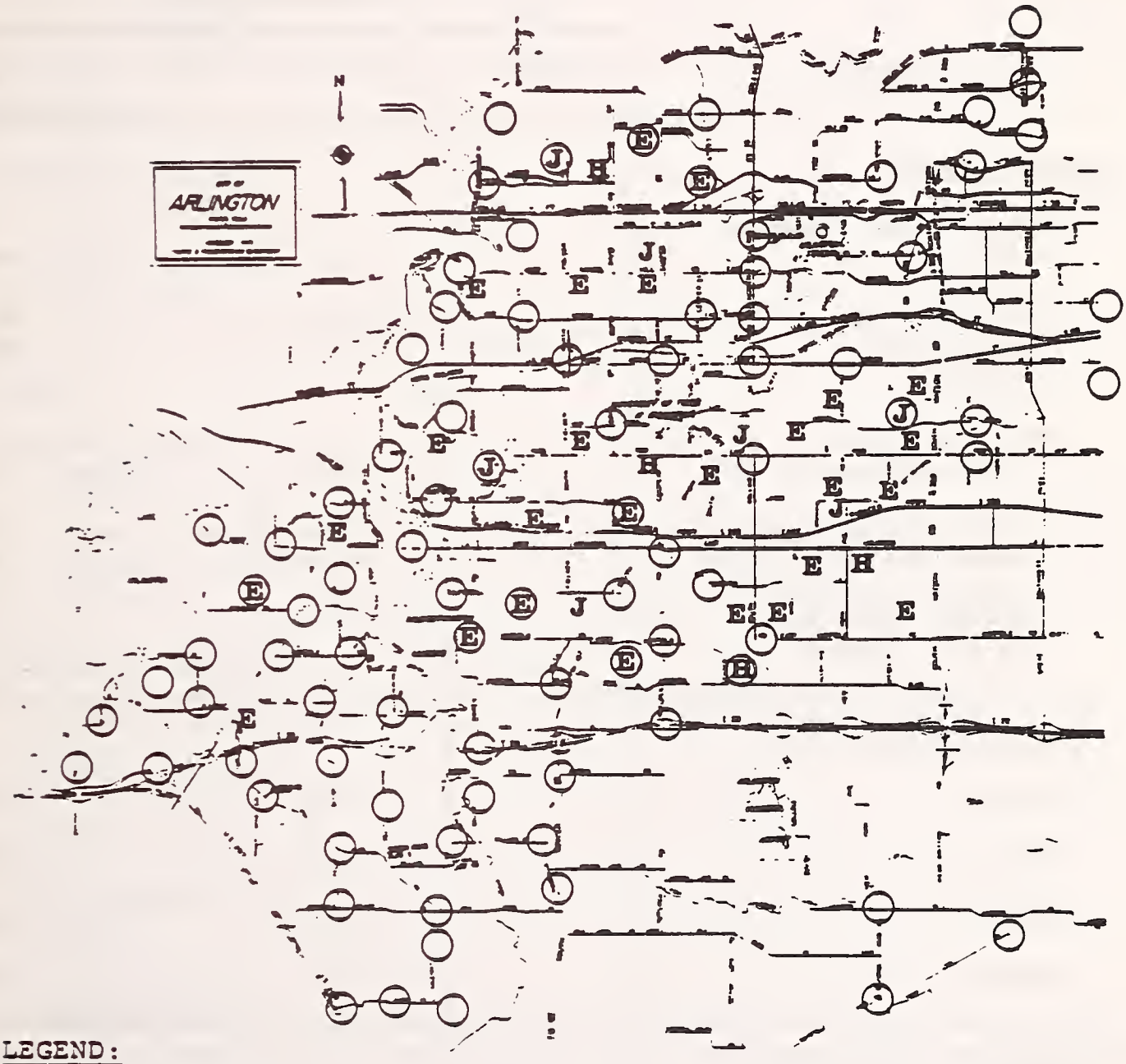
15 Note in this case that vehicles released by the employment of the transportation center concept were not used for any other purpose. In this case, they may either be sold by the school district or be used to delay purchase of new buses as older ones become unserviceable.

EXHIBIT 38

AISD SCHOOLS AND TRANSPORTATION CENTERS
Alternative #2



LEGEND:

H - High School

J - Jr. High School

E - Elementary School

◯ - Transportation Center

EXHIBIT 39 (Part I)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #2: Energy Conservation - Modified School Bus Routes

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)		+765.7		+765.7
private auto		+967.7		+967.7
school bus		-202.0		-202.0
transit				
Fuel Consumption (1000 gallons/yr)		+12.3		+12.3
private auto (gasoline)		+57.1		+57.1
school bus (gasoline)[2]		-40.9		-40.9
school bus (diesel)[2]		-3.9		-3.9
transit (gasoline)				
transit (diesel)				
Monetary Costs ($1000)				
Capital		-19.5		-19.5
Operating		-205.3		-205.3
Revenue		-130.5		-130.5
Deficit		-94.3		-94.3
Mobility (1000 trips/yr)				
New Transit Trips		-286.7		-286.7
Induced Trips				
School Bus Trips[3]		-255.0		-255.0

EXHIBIT 39 (Part 2)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #2: Energy Conservation - Modified School Bus Routes

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)		-2.6		-2.6
Temporal Coverage (hours/day)				
Safety				
Street Crossings (1000/day)		+7.1		+7.1
primary streets		+2.2		+2.2
secondary streets		+4.9		+4.9
Efficiency & Capacity				
Passengers/Vehicle Hour		80.8		80.8
Cost per Passenger ($)		0.26		0.26
Deficit/Passenger ($)		0.16		0.16
Fuel Saved/Deficit (gal/$)		+0.13		+0.13
System Capacity (passengers/day)		5,300		5,300

[1] All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped.

[2] Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

[3] Includes only home-to-school trips by "eligible students" on school bus on the community transit service.

parents, the costs of operation, and the safety of students. In general, the results of this alternative were negative (having a disadvantageous impact on users and the school district) with the exception of costs to the school district. Even fuel consumption benefits from reduced vehicle miles traveled were offset by the increase in chauffeured trips made by parents of students.

The reduction in vehicle requirements, vehicle hours, and vehicle miles traveled resulted in significant cost savings. The school district was able to reduce its transportation expenditures by $205,300 (24% of the total budget for school bus operations). On the other hand, since the number of vehicle miles were reduced, reimbursement from the state also decreased. Using the 1979-80 school year reimbursement formula, the state reimbursement was reduced by $130,500.[16] Nonetheless, the school district still gained on a monetary basis from these changes.

With the longer walk distances, children were required to cross more streets between their homes and the bus stops. Street crossings, divided into primary (arterial) and secondary (local residential) street categories, increased by approximately 270% in total. Primary streets accounted for approximately 20% of the increase, increasing from an average of 0.02 per student with existing routes to over 0.30 per student. It was apparent this could cause severe repercussions from concerned parents if they felt the changes were unnecessary.

Finally, there was a direct reduction in school bus driver employment by the school district. As a result of the changes, some 15 employees of the school district lost part time jobs. The reduction in payroll was $78,110.

Alternative #3

The final energy conservation alternative was to combine the reduction in school bus usage with the implementation of other transportation service to residents of the city and the faculty and staff of the university. The basic tenet of this

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16 With the 1978-79 school year formula, which is not based solely on miles traveled, the loss of revenue is somewhat less.

proposal was that while reduction in school bus service alone resulted in increased fuel consumption, the shifting of these vehicles to more productive uses might counteract these impacts and result in a service which, on the whole, reduced fuel consumption.

The third alternative consisted of three services integrated into a single operation through the use of the same vehicle fleet. The Arlington Independent School District provided home-to-school transportation for those students carried in the existing system, using the transportation center approach. Residents of the City of Arlington received conventional fixed-route transit for intra-community trips, also based around the transportation centers. Finally, students of UTA were provided a shuttle service within the campus, especially to connect fringe area parking facilities with the center of the campus.

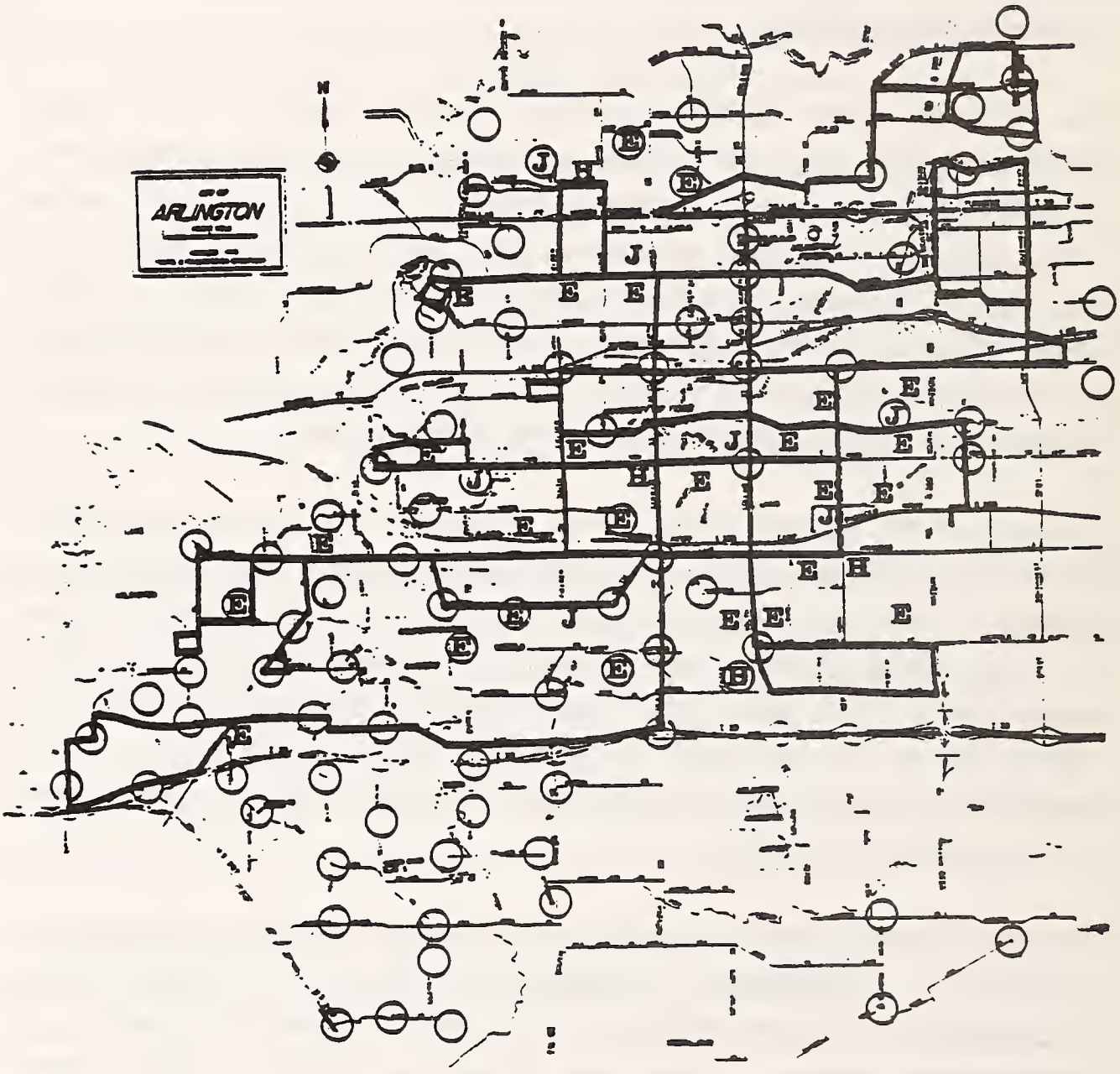
The basis of this alternative was the set of transportation centers illustrated in Exhibit 40. (This figure also presents peak route coverage.) This set of bus stops consisted of those identified in the previous alternative plus a number of other locations serving population and employment centers where no public school students using school buses lived. These additional transportation centers were located primarily in the center of Arlington, where a large portion of the population resides, and in the Great Southwest Industrial Park area, site of most of the employment in the area.

Unlike the combined services based around transportation centers, as discussed in NCTCOG's A Metropolitan Transportation Plan for National Energy Contingencies, it was not possible to have community fixed routes serving all transportation centers. There were simply too many bus stops located throughout the service area to develop a workable system design. Instead, fixed route service was designed to cover only a portion of the transportation centers. These routes were then used to transport both the general public and students traveling between certain transportation centers and schools along their routes.[17] The remaining Arlington School District students were transported on

[17] Note under present statutes, the mixing of general public and student transportation would not be allowed. This restriction is discussed in the appendix. For the purpose of this analysis, the constraint is not considered.

EXHIBIT 40

PEAK/SCHOOL BUS TRANSIT COVERAGE
Alternative #3



LEGEND:

H - High School

J - Jr. High School

E - Elementary School

○ - Transportation Center

Ⓗ - Transportation Center/
High School

a set of supplementary routes serving those transportation centers and schools not located along any of the routes. Exhibits 40 and 41 present the fixed routes which served both school children and the general public during peak and off-peak hours, respectively. During peak hours there were seven routes oriented primarily around the Great Southwest Industrial Park. Off-peak the emphasis shifted to the two major shopping malls as one route was completely eliminated and the extensions of routes into the employment center were suspended. Routes were also shortened in the less heavily populated and more wealthy western portions of the city. Peak hour service incorporated nine school bus routes, 23% of those operated under Alternative #2. The remaining 32 school bus routes (plus those and special needs students) continued to be operated in the same manner as in the previous alternative.

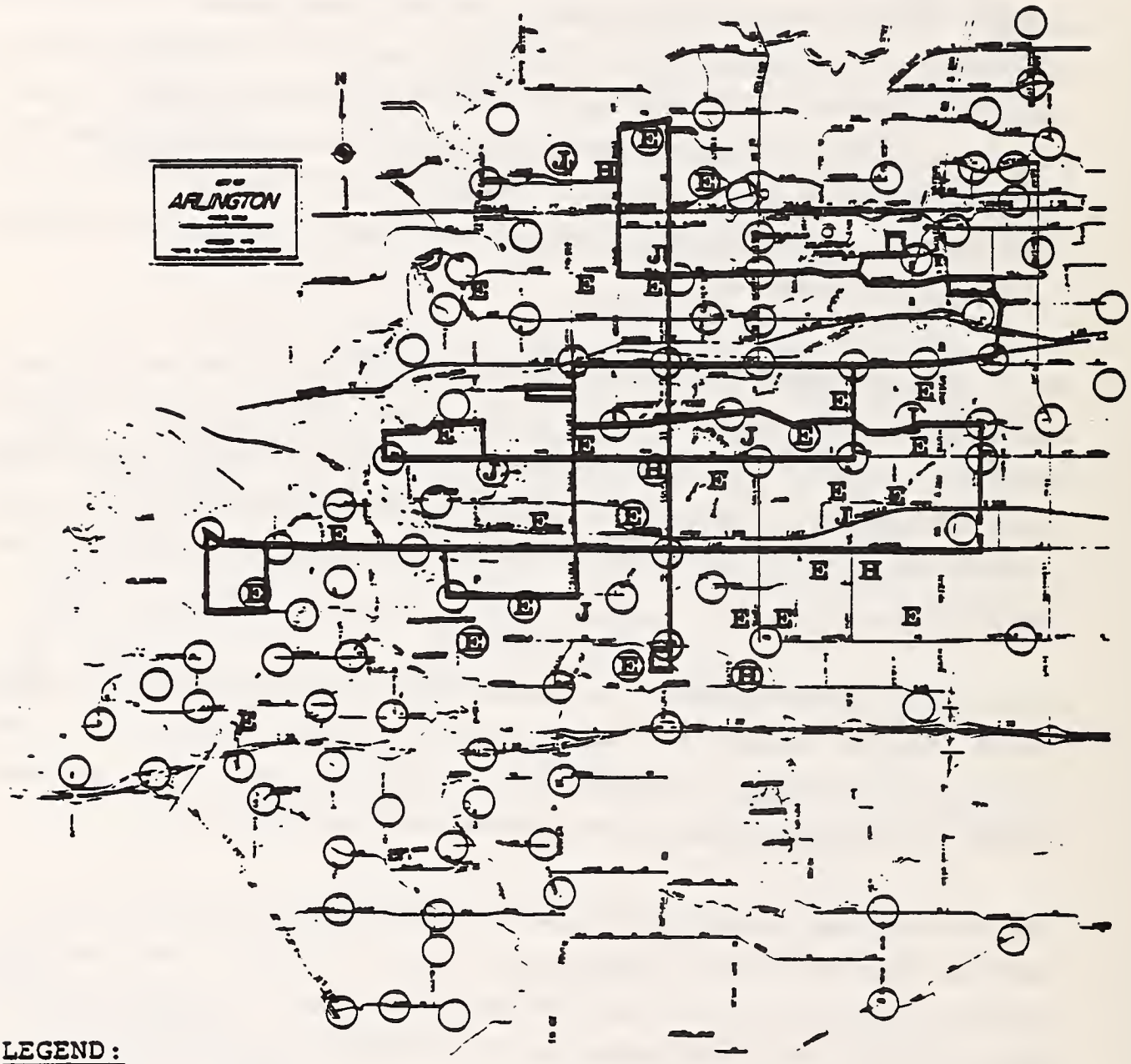
On the 32 supplemental routes, only school children were allowed to ride. As a result of the short distances covered by these routes and their lack of relationship to general public travel patterns, opening them to the general public would have generated little additional ridership. The benefits from such a small increase were insufficient to justify the expense of fare collection facilities necessary.

Intra-campus transportation for the university was provided by two of the fixed routes traveling through the campus. Each of these routes took a more circuitous path through the campus than necessary in order to stop at major parking facilities, residences, and the central portion of the campus.

All three of these services were operated together using several 84 capacity vehicles which would have otherwise been used for regular school operations. Certain modifications were made to the existing fleet to accommodate the general public. One modification was the installation of a lock box for fare collection. To keep this a low-capital option, the fare boxes provided were basically very simple. While they did not provide many options desirable in conventional transit services (such as automatic counting and a significant degree of protection from theft by persons charged with farebox maintenance

EXHIBIT 41

OFFPEAK SCHOOL BUS TRANSIT COVERAGE
Alternative #3



LEGEND:

H - High School

J - Jr. High School

E - Elementary School

○ Transportation Ctr.

and fare removal) they did provide a safe storage system for money while on the vehicle. A second modification to the vehicles was a slight increase in the distance between seats. Two rows of seats were removed and other seats were spread out through the vehicle, increasing the distance between seats from 25 inches to 28.5 inches. This also reduced the vehicle capacity to 72 children or 48 adults.

Service on the general public routes was provided at 45-minute headways during peak hours (6 a.m. to 9 a.m. and 3 p.m. to 6 p.m.) and 60-minute headways off-peak (9 a.m. to 3 p.m.).[18] A fare of 40¢ was charged to the general public; elderly adults and young children rode for 20¢. A 5¢ fare was charged for transfers by the general public. No weekend or holiday service was provided. Students traveling to and from the AISD schools during approved hours rode free, and travel within the UTA campus was provided at no charge to the user.[19]

A minimal level of coordination between the general public routes was performed. Since routes vary significantly in length, it was impossible to have the same round trip time necessary to provide full coordination. Instead, pairs of routes were formed such that their combined running time equaled two headway intervals. In this manner, all conventional routes could operate at the same headway. For example, Route #1 had a round trip time of 63 minutes during peak period and Route #7 had a trip time of 108 minutes. By having two vehicles each running on these two routes alternately, the total round trip time equaled 180 minutes. Each route was operated on a 45 minute headway with Route #7 beginning at 6 a.m. while Route #1 started at 6:20 a.m. This route scheduling resulted in high frequency service between the industrial park and the center of the city and within the UTA campus.

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18 The headway employed was based on a screening analysis of ridership and vehicle requirements. The service chosen here was the most efficient possible. This screening analysis is discussed later in this section.

19 This choice of fare was made to assure comparability between this and the base case.

Exhibit 42 presents the impacts resulting from the combined community transportation service. In this alternative the energy consumption impacts were positive, as a sufficient number of individuals were diverted from their automobile to make up for the extra fuel consumed in the provision of the fixed routes.

A total of 14,400 gallons of fuel per year were saved through the implementation of this alternative. This was broken into an added consumption of 15,200 gallons to operate the service, 64,200 gallons saved by persons shifting their travel choice from auto to bus (including UTA shuttle users), and 22,500 gallons saved by persons no longer taking a trip or combining this trip with others due to a change in auto availability.

As a result of the available capital equipment and the combined use of resources, the cost of this operation to the city was only 53% of operating an independent service.[20] In addition to reducing the cost to the City, the shuttle service on the UTA campus also operated 48% more cheaply. While no significant reduction in costs to the Arlington Independent School District beyond that produced in the previous alternative was obtained, additional revenues were received from the City and UTA to cover fixed costs (i.e., vehicles) and operating costs. These, in addition to the changes in direct operating costs over existing conditions, amounted to 14% of the total AISD transportation costs.

The mobility impacts of this alternative included a reduction in ridership by "eligible" AISD students and the generation of general public and UTA student ridership. The most important aspect of these impacts was that the system did not generate as much ridership as did the baseline alternative, despite an increase in the total bus miles traveled. This reduced level of demand resulted primarily from the lack of coverage of the system and the longer peak hour headways. A comparison of the accessibility impacts indicated that, despite

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20 Costs are attributed to the incidence groups on the basis of the use of the service by each group's constituents. Costs related to the portions of runs which are part of school bus delivery are attributed to the school district; the extra route mileage for deviations on the UTA campus are charged to UTA; the remainder are placed in the City's column.

EXHIBIT 42 (Part I)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #3: Energy Conservation - Combined Services

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)	-945.2	+781.9	+10.0	-153.3
private auto	-1,439.8	+967.7	-11.8	-483.9
school bus	+494.6	-185.8	+21.8	+330.6
transit				
Fuel Consumption (1000 gallons/yr)	-26.8	+11.6	+0.8	-14.4
private auto (gasoline)	-84.9	+57.1	-1.8	-29.6
school bus (gasoline)[2]		-46.3		-46.3
school bus (diesel)[2]	+58.1	+0.8	+2.6	+61.5
transit (gasoline)				
transit (diesel)				
Monetary Costs ($1000)				
Capital	+5.0			+5.0
Operating	+422.8	-198.6	+20.3	+244.5
Revenue	+170.4	-114.8		+55.6
Deficit	+252.4	-83.8	+20.3	+188.9
Mobility (1000 trips/yr)				
New Transit Trips	+490.5	-286.7	+95.4	+299.2
Induced Trips	+43.3			+43.3
School Bus Trips[3]		-255.0		-255.0

EXHIBIT 42 (Part 2)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #3: Energy Conservation - Combined Services

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)	+59.4	-2.6		+56.8
Temporal Coverage (hours/day)	+12.0		+12.0	+12.0
Safety				
Street Crossings (1000/day)		+7.1		+7.1
primary streets		+2.2		+2.2
secondary streets		+4.9		+4.9
Efficiency & Capacity				
Passengers/Vehicle Hour	19.0	76.5	39.4	50.6
Cost per Passenger ($)	0.87	0.26	0.21	0.48
Deficit/Passenger ($)	0.51	0.16	0.21	0.30
Fuel Saved/Deficit (gal/$)	+0.11	+0.14	-0.04	+0.08
System Capacity (passengers/day)	17,105	5,166	4,940	27,211

[1] All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped.

[2] Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

[3] Includes only home-to-school trips by "eligible students" on school bus on the community transit service.

greater route mileage, fewer people live within an easy walking distance of the bus stops under this alternative. This is a direct result of restricting bus stops to the transportation centers, and accounts for approximately 75% of the difference between the services. If the shorter headways were also scheduled (without shortening routes) total ridership on the transportation-center-based system would have increased by 23%. Such a modification, however, was judged to be inefficient in the screening analysis of vehicle productivities at various headways.

The final major impacts of this alternative are safety and employment. A significant increase in street crossings (over the existing conditions) resulted from using the transportation center. This is the same as noted in the previous alternative. Employment, on the other hand, was increased by almost 5% with an additional $26,400 in payrolls to Arlington Independent School District employees.

Alternative #4

The baseline alternative for energy contingency plans is the same as the baseline alternative (Alternative #1) for energy conservation measures. In this case, the major difference is that there are very strong external forces, specifically the unavailability of fuel, which drive persons to use of the transit service. The major issue is whether this abnormally high demand can be adequately handled by the alternative in a cost-effective manner.

Exhibit 43 presents the results of the energy contingency analysis performed for this system design. The energy shortage impacted not only the newly-provided City and UTA services, but also the school district bus routes as a result of an increase in ridership.[21] In this alternative, there was a total reduction in fuel consumption (from all aspects of the service and other individual actions) of 3,083,100 gallons amounting to 15% of total use. This was a direct result of the

[21] These impacts were not all identified as part of the impacts matrix because they were part of the "existing conditions."

EXHIBIT 43 (Part I)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #4: Energy Contingency - Conventional Approach

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)	-240.5		+16.0	-224.5
private auto	-665.9		-9.9	-675.8
school bus				
transit	+425.4		+25.9	+451.3
Fuel Consumptions (1000 gallons/yr)	-2.0		+2.0	0
private auto (gasoline)	-40.7		-1.5	-42.2
school bus (gasoline)[2]				
school bus (diesel)[2]				
transit (gasoline)			+3.5	+3.5
transit (diesel)	+38.7			+38.7
Monetary Costs ($1000)				
Capital	+65.0			+65.0
Operating	+621.1		+38.9	+660.0
Revenue	+236.6			+236.6
Deficit	+449.5		+38.9	+488.4
Mobility (1000 trips/yr)				
New Transit Trips	+681.2		+87.5	+768.7
Induced Trips	+458.2			+458.2
School Bus Trips[3]				

EXHIBIT 43 (Part 2)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #4: Energy Contingency - Conventional Approach

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)	+91.5			+91.5
Temporal Coverage (hours/day)	+12.0		+10.5	+12.0
Safety				
Street Crossings (1000/day)				
primary streets				
secondary streets				
Efficiency & Capacity				
Passengers/Vehicle Hour	30.0	51.4	38.6	45.2
Cost per Passenger ($)	1.01	0.30	0.45	0.48
Deficit/Passenger ($)	0.66	0.15	0.45	0.23
Fuel Saved/Deficit (gal/$)	0.00	0.00	-0.05	0.00
System Capacity (passengers/day)	24,510	6,700	661	31,871

[1] All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped.

[2] Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

[3] Includes only home-to-school trips by "eligible students" on school bus on the community transit service.

fuel shortage. The 15% reduction in fuel consumption resulted primarily from actions taken independently by motorists, such as the linking of several trips into one multipurpose trip, the elimination of some discretionary trips, and the formation of carpools. These actions to a large extent were unaffected by the provision of the service prescribed by this alternative.

It should be noted that almost any alternative under these conditions would result in the same impact on energy. Even if no action were taken by the government or potential transportation providers, a total reduction in fuel consumption of the 15% availability shortfall would result. In the case in which governmental or other actions were taken, it was assumed fuel for these purposes would come from a common pool.[22] As a result, any fuel consumed by public transportation services would reduce that available to the private motorist. Fuel saved by those who switch from their private vehicle to the public transit services would have been used by other persons who otherwise would not have been able to obtain fuel.

Given this process, it was relatively unimportant to examine the individual impacts on fuel consumption of the various portions of this alternative. The most important consideration was the amount of fuel consumed by the "public sector." A total of 42,200 gallons or 0.2% of total available supplies were removed from the private market to operate all three services in this alternative. On the other hand, patrons of the transit service reduced their own consumption of gasoline by 166,000 gallons. The net result was that 124,000 gallons of fuel were released for other uses.[23]

The major impact of the provision of public transportation in the time of an energy crisis was assumed to be the mobility benefit provided. As a result of the

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22 Note this model of fuel shortfalls was slightly inaccurate due to the restrictions in the ability of refiners to instantaneously shift fuel production to provide a greater amount of diesel fuel. Furthermore, some minimal changes would result from the greater yield of these lower grade petroleum products from a barrel of crude oil.

23 Assuming diesel and gasoline can be directly interchanged.

fixed routes operated by the City of Arlington, a total of 681,200 trips on an annual basis were no longer taken by the automobile.[24] An estimated 30% of these trips would not have been made due to the fuel shortfall. In addition, 52,900 trips annually were taken by the transportation disadvantaged who could not have taken their trips even if sufficient quantities of fuel were available. Since trips on this service were all made entirely within the city limits, they represent shorter distances than the average trips by residents of Arlington. As a result, it is likely that these trips actually diverted from auto during an energy crisis would be replaced in the private sector by a fewer number of longer trips. In effect, these trips by automobile could be considered induced travel resulting from the city-provided service. This impact was measured in Exhibit 43 under total induced trips.

In response to the fuel shortfall, an increase in ridership also was noted on the AISD school bus service. Since the service was not altered between this alternative and existing conditions, no change in the measured impacts resulted. An additional 735 students used the school bus service per day, thereby increasing fuel availability by 27,800 gallons (enough for 475 trips per day). Note this impact occurred without the implementation of any alternatives; therefore, it does not appear in Exhibit 43.

The shuttle service provided by the University of Texas at Arlington did not have direct impact on the use of the automobile for commuting trips. All persons using this service had to continue using their automobiles as the primary mode. While an increase in carpool formations might be noted, this change would not have differed from the existing conditions (without the shuttle service). The increase in carpooling was solely a function of the decreased fuel availability, not of this transportation alternative. The benefit the shuttle service did have was that less fuel was consumed searching for centrally located parking.

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24 Data from Dallas and Fort Worth indicate the energy crisis in the summer of 1979 (approximately a 15% shortfall nationally) resulted in between a 10% and 21% increase in transit ridership. This analysis used a 15.6% increase to estimate impacts.

Unfortunately an estimated 2,000 extra gallons of fuel was consumed by the shuttle service, which might have been translated into a decrease of 6,000 trips made by residents of the region on an annual basis. It should be noted that much of this fuel would be purchased in areas outside the city of Arlington (in communities where commuting students live) and, therefore, may not have had a direct impact on the general public being considered in this study.

One interesting phenomenon noted in comparing the use of the shuttle service between this alternative and the energy conservation situation was that fewer students chose to use the service under the conditions being modeled here. Two forces affected this difference in ridership. On one hand, the shortage of fuel provided an incentive for students not to spend much time searching for spaces in the closer lots. As a result, the average usage of the centrally located parking facilities was expected to be slightly lower than under normal conditions. (Empty spaces were not taken as quickly.) On the other hand, the shift in travel patterns towards the use of carpooling in an energy emergency decreased the total number of automobiles arriving on campus. This reduction in need for parking on campus had a greater impact on the usage of outer lots (down almost 50%) than the increased incentive of using these lots.

Other impacts of this alternative were largely the same as those described in the energy conservation baseline alternative. Approximately 58% of the general population and 50% of the transit captive population lived within easy walking distance of the transit service. Employment and cost impacts were also relatively large as a result of baseline service provided. One difference was the amount of revenue generated by the fixed route system. The 13.7% higher ridership resulting from the fuel shortage accounted for $27,900 additional revenue. This reduced the net cost of the service to $449,500 (only $0.66 per passenger carried).

Alternative #5

This alternative approach to dealing with an energy emergency used the same techniques as the third alternative for the energy conservation conditions. In

this case, the combined provision of services for the city, the AISD, and UTA were in response to a short term situation. As such, some of the more long term changes in school buses and other facilities were not made.

Provision of the service followed the same lines as that described earlier. The primary difference was that no modifications were made to the existing vehicles. No fare box was added to the vehicles, resulting in a potential security problem; however, the short term nature of this alternative indicated that the capital costs and the required lead time for vehicle modification were not justifiable. Some discomfort was also created by the failure to increase spacing between seats. Under normal conditions this could act as a severe disincentive, but given the significant shortage of fuel this should not have presented major difficulties.[25]

Exhibit 44 presents the results of the combined services alternative. The results tended to be similar to the previous alternative, except for the costs of operating the service. As was the case in the conventional transit alternative for energy contingencies, the total consumption of fuel was reduced by the 15% shortfall. In this case, however, less fuel was consumed in the provision of public transportation services, as fewer vehicle miles were operated. A total of 24,300 additional gallons (0.06%) of fuel were used in the publicly provided service. At the same time, a smaller number of persons were diverted to using the community bus service. These persons reduced their fuel consumption by 93,300 gallons on an annual basis. Thus, the net savings as a result of the public transportation allowed an additional 244,000 trips to be made by the general public on an annual basis. In addition, some 87,800 trips which would not have been made, even if fuel were available, were generated.

Positive mobility impacts were noted with respect to both the general public and UTA shuttle services. On the general public system 1,460 trips per day were made by people who previously would have used their automobiles. An additional

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25 Use of school buses for short time in Miami, Florida, and other areas indicates that individuals would be willing to ride unmodified school vehicles.

EXHIBIT 44 (Part I)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #5: Energy Contingency - School Bus Approach

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)	-140.7	+67.9	-8.0	-80.8
private auto	-630.6	+244.1	-22.9	-409.4
school bus	+489.9	-176.2	+30.9	+344.6
transit				
Fuel Consumption (1000 gallons/yr)	+27.5	-28.6	+1.1	0
private auto (gasoline)	-37.2	+14.4	-1.5	-24.3
school bus (gasoline)[2]		-43.8		-43.8
school bus (diesel)[2]	+64.7	+0.8	+2.6	+68.1
transit (gasoline)				
transit (diesel)				
Monetary Costs ($1000)				
Capital				
Operating	+436.3	-184.0	+20.3	+272.6
Revenue	+193.8	-108.1		+85.7
Deficit	+242.5	-75.9	+20.3	+186.9
Mobility (1000 trips/yr)				
New Transit Trips	+557.7	-100.9	+72.2	+529.0
Induced Trips	+331.8			+331.8
School Bus Trips[3]		-89.7		-89.7

EXHIBIT 44 (Part 2)

COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX
Alternative #5: Energy Contingency - School Bus Approach

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)	+59.4	-2.6		+56.8
Temporal Coverage (hours/day)	+12.0		+12.0	+12.0
Safety				
Street Crossings (1000/day)		+7.1		+7.1
primary streets		+2.2		+2.2
secondary streets		+4.9		+4.9
Efficiency & Capacity				
Passengers/Vehicle Hour	20.9	101.4	29.8	81.5
Cost per Passenger ($)	0.78	0.20	0.28	0.46
Deficit/Passenger ($)	0.44	0.11	0.28	0.31
Fuel Saved/Deficit (gal/$)	-0.11	0.38	-0.05	0.00
System Capacity (passengers/day)	17,105	5,435	4,940	27,480

[1] All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped.

[2] Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

[3] Includes only home-to-school trips by "eligible students" on school bus on the community transit service.

626 trips would not have been made in the absence of public transportation. The UTA shuttle portion of the fixed routes attracted 334 riders per day. All of these riders would have otherwise walked to campus. The only fuel saving resulting from the intra-university transit use was that due to reduced deadheading in centrally located parking lots. This saving (excluding fuel to operate the shuttle service) amounted to 1,500 gallons on an annualized basis (not enough to offset the extra fuel to provide the service).

A major negative impact of this alternative was the increase in walk distance and thus a reduction of ridership by AISD students. While the impact was not as dramatic as in the normal fuel conditions alternative, approximately 5% fewer students chose to travel by school bus.[26] Their transportation was replaced by parent transportation which consumed an additional 414,000 gallons of fuel on an annual basis. The increased walk distance also had a negative impact on student safety, as they were forced to cross a greater number of streets. Especially notable were the additional 2,900 primary arterial streets crossed per day (approximately one out of every four students must cross an additional major street).

The most beneficial aspects of this service were its cost and flexibility. The productive use of available vehicles allowed this service to be provided for an additional $186,900 per year. This amounted to only $0.35 per additional passenger carried and only $0.50 per trip (both auto and transit) which would not have otherwise been made. The ability to implement this alternative from an operational viewpoint in an extremely short period of time also was an advantage. No long term commitments must be made by local agencies to provide for the needs during short-lived difficulties. This alternative did not require the purchase of additional vehicles or hiring of new drivers which would not be needed two or three months later.

One potential drawback to this approach to an energy crisis was the restrictive capacity of the system. During peak periods, heavy ridership was noted on all

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26 By assumption.

vehicles on school portions of the run and near major employment centers. Average load factors in the mornings were greater than 30%, which is quite high for a service of this nature. This restriction could prove to be a major problem were the fuel shortfall to reach somewhat greater propertions.[27] It is estimated that this service would be unable to handle peak period demand if a 20% to 25% shortfall were encountered. No such problem would be encountered during off-peak periods due to the number of vehicles available. A possible solution in capacity constrained situations is the use of taxi company vehicles to operate over the same fixed routes.

Analysis

The impacts of these alternative service designs are shown in Exhibit 45. The methodology for estimating the values of parameters shown in the exhibit is documented in Appendix B of this report.

The analysis showed that, if each of the three entities pursued its own transit plan (the "Conventional Approach"), the greatest energy savings would result under normal fuel conditions. The second alternative, based on a more fuel efficient school bus operation, was shown to have an overall net increase in fuel consumption due to more parents driving their children to school. The data showed that while the school district would save 40,900 gallons of fuel per year, the private consumption of fuel would increase by 57,100 gallons per year. It should be pointed out that an assumed elasticity with respect to walking distance for the school children is a key factor in these results.

Looking at the cost effectiveness of the alternatives (Exhibit 46) reveals that none of the alternatives can be justified on fuel conservation grounds since the cost of saving a gallon of fuel in this way exceeds the cost of the fuel itself. The cost-effectiveness analysis also shows the merits of the integrated community

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27 This is also a problem if the increase in ridership resulting from an energy emergency is closer to the 750 to 2,600 per day which would be estimated using the frequency of extra transit travel during the 1979 fuel shortage in Dallas and Fort Worth. (Such a figure in this case is likely to be high as a result of the inability of this service to carry passengers to locations outside Arlington.)

EXHIBIT 45

IMPACTS OF ALTERNATIVE SERVICE DESIGNS

Impacts:	Alternatives: Energy Conservation #1	#2	#3	Energy Contingency #4	#5
Change in Fuel Consumption (,000 gal/yr)	-52.5	+12.3	-14.4	0.0	0.0
Gasoline	-91.2	+16.2	-75.9	-38.7	-68.1
Diesel	+38.7	-3.9	+61.5	+38.7	+68.1
CITY	-54.0	0.0	-26.8	-2.0	+27.5
AISD	0.0	+12.3	+11.6	0.0	-28.6
UTA	+1.5	0.0	+0.8	+2.0	+1.1
Private	-94.7	+57.1	-29.6	-42.2	-24.3
Pulic	+42.2	-40.9	+15.2	+42.2	+24.3
New Transit Trips (,000/yr)	+714.7	-286.7	+299.2	+768.7	+529.0
CITY	+599.1	0.0	+490.5	+681.2	+557.7
AISD	0.0	-286.7	-286.7	0.0	-100.9
UTA	+115.6	0.0	+95.4	+87.5	+72.2
Induced Trips (,000/yr)	+52.9	0.0	+43.3	+458.2	+331.8
"Eligible" School Trips (,000/yr)	0.0	-255.0	-255.0	0.0	-89.7
Total Operating & Annualized Capital Cost ($,000/yr)	+725.0	-224.8	+249.5	+725.0	+272.6
CITY	+686.1	0.0	+427.8	-686.1	+436.3
AISD	0.0	-244.8	-198.6	0.0	-184.0
UTA	+38.9	0.0	+20.3	+38.9	+20.3
Locally Funded Net Total Annual Cost ($,000/yr)	+516.9	-94.3	+188.9	+488.4	+186.9
CITY	+478.0	0.0	+252.4	+449.5	+242.5
AISD	0.0	-94.3	-83.8	0.0	-75.9
UTA	+38.9	0.0	+20.3	+38.9	+20.3

EXHIBIT 46

COST EFFECTIVENESS OF THE COMMUNITY BUS ALTERNATIVES

Alternative	Cost/Gallon Saved ($)	Cost/New Transit Trip ($)
Energy Conservation Scenario		
1. Conventional Approach	13.81	1.01
2. Modified School Bus	N/A	N/A
3. Combined Transit Service	17.33	.83
Energy Contingency Scenario		
4. Conventional Approach	N/A	.94
5. Combined Transit Service	N/A	.52

bus system (alternatives 3 and 5) in terms of attracting additional transit riders at a lower cost than the conventional alternatives (1 and 4).

INSTITUTIONAL CONSIDERATIONS

In full appreciation of the possibility that institutional considerations would overshadow technical problems in the study of integrating various local institutions into a community-wide transportation system, a separate consultant was retained to document these non-technical issues. The discussion which follows is based in large part on the excellent job this consultant did.[28]

Community Bus Strategy

It appears that the strategy of approaching the study as an integrated community transportation system study rather than as simply one of utilizing the Arlington Independent School District buses for emergency use was useful in gaining the participation of the organizations involved. As could be expected, there was some concern over who would actually be responsible for the operation of this integrated community transit system, particularly from those who would have the biggest stake in the operation. But, as one of the representatives from the university said, "If its (the study's) purpose is to come up with a system of using school buses for public transportation, then I don't think it's going to work. If its aim is to design a true community transit system, then that could work."

Role of NCTCOG

In attempting to gain the participation of the different institutions involved, NCTCOG tried to turn over as much responsibility for guiding the study to the study participants as possible. In this particular project, however, the institutional consultant felt that NCTCOG went too far in this regard, and a "leadership vacuum" was created in the project. Since each of the study participants (the city, the university, and the school district) were approaching the study from an equal footing, none of them wanted to provide the degree of

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28 William E. Sloan, Institutional Factors in a Case Study of the Use of School Buses in Energy-Related Transportation Planning. Prepared for the North Central Texas Council of Governments. January, 1980.

leadership necessary to make the study effort as productive as possible. In essence, then, NCTCOG may have been overly cautious in respecting the interests of the individual study participants.

Organizational Representatives

The study panel was made up of representatives from the university, the city and the school district. While this is quite logical, some interesting difficulties were brought about by the fact that the representatives came from different levels of their organizations and thus had different perspectives on the study and its objectives.

Perhaps the most dramatic illustration of how different people within an organization have different perspectives is illustrated by the UTA representatives on the study committee. Initially the university was represented by the vice president of business affairs. This individual saw value in the study because it could provide additional access to the university for potential students who do not have automobiles. The study also could possibly lead to a bus circulation system to provide a shuttle from the university's parking lots to the campus buildings. An interview of this university vice president by the consultant at the initiation of the study found that there was some rethinking going on with regard to the parking problems at the university. (Of the 19,000 1979 fall semester students 90% were commuters.) "We may have created part of our problem for ourselves by providing too much parking," admitted the university representative.

By the end of the study effort, the vice president of business affairs had turned over his position on the study panel to the university's chief of police. Since the largest function within the university police department is the patrolling of on-campus parking, it is not surprising that this representative had a different perspective with regard to suggestions to reduce parking. At a meeting of the study panel with the technical consultant, this individual reacted "strongly and negatively" to a suggestion that some on-campus parking be eliminated to encourage students to take a fresh look at alternative forms of transportation.

"We would be cutting off our noses to spite our faces if we eliminated on-campus parking," the police chief said. "I think we would be sure to lose enrollment."

Communications

Some communications difficulties arose because of the mixture of lay individuals with transportation experts in the study. The institutional consultant reported that these communication gaps were "most noticeable with regard to the school district and university representatives to the panel and with the technical consultant." The technical consultant tended to concentrate on the physical design aspects of the integrated transportation system and suggested that the institutional issues such as laws, regulations, etc. were essentially insurmountable. On the other hand, the members of the panel tended to view these regulatory issues as being the principal problems to be solved.

One of the most unfortunate portions of the study was the consultant selection process. Neither the university nor the school district representatives were familiar with the transportation consultants who submitted the proposals nor had they participated in a consultant study before. A strong difference of opinion developed between the city representative on the one hand and the university and school district representatives on the other with regard to the best choice in consultants for the study. Eventually the university and school district representatives agreed to go along with the choice of the city representative. This was based upon their appreciation of the City representative's greater familiarity with the consultants and this type of study. This, however, created a feeling of ill will toward the study which unfortunately led to some changes in representation and which was difficult to overcome.

Proper Frame of Mind

One of the problems of energy contingency planning is maintaining a frame of mind with regard to what is possible to do during fuel shortages. At the beginning of the study, much of the panel felt that it would be difficult to institute certain actions because of public resistance, etc. However, during the course of this particular study, the Arlington area experienced a severe gasoline shortage (as did other parts of Texas and the U.S. during the summer of 1979).

In one of the panel meetings during this shortage, the school district representative remarked that his gasoline allocation for the school buses had been rejected, and this had created some concern for him. Likewise the university representative explained that his patrolmen were forced to park their cars and cover their beats on foot in an effort to save gasoline. The city representative noted similar actions on the part of the city police.

The institutional consultant pointed out that the fuel shortage raised the level of importance of the study. It may also have had the effect of clouding the overall purpose of the study. The "easy assumptions" of a few months earlier with regard to the responsiveness of the public to the provision of public transportation, etc. no longer seemed to be applicable.

Role of Technical Consultant

In retrospect it appears that the technical consultant may have been engaged too early in the study or perhaps that a consultant with more experience in the field of public administration may have been more appropriate. There appear to have been too many unresolved issues with regard to the organization of an integrated bus system to permit the technical consultant to design the transit system in a way that would be acceptable to all concerned.

OUTLOOK FOR IMPLEMENTATION

In general it appears that the study panel was disappointed in the results of the technical study. Whether this is the result of too high expectations on the part of the panel members or too limited a scope for the technical study is not clear, and, in fact, the truth probably lies somewhere in between.

It is unlikely that the integrated system designed by the consultant will ever be implemented exactly as proposed. However, it is also true that to some extent a better understanding of the mutual transportation problems which the city, the university, and the school district share has resulted from the study. This is summed up best by the original university representative: "It (the study) may

create a greater level of awareness that steps can be taken to solve common problems just by allowing us to think about some of the things we can do." The second representative added, "It (the study) has made us recognize that some of our problems are mutual and that solutions can come easier through cooperative effort."

The principal obstacle to implementation seems to be the lack of an implementing agency with the authority and interest for piecing together an integrated community transit system.

VI. IMPROVEMENTS TO THE PLANNING PROCESS

NCTCOG EXPERIENCE

The energy contingency planning studies described in this report have been useful in identifying the issues which must be dealt with in such planning efforts for transportation. For ease of discussion, these issues have been categorized as being either technical or institutional. However, at times this distinction is not precise.

Technical Issues

Traditional urban transportation planning often lacks an appreciation of the many transportation resources which are available in the community. This becomes a limitation in analyzing the transportation system in energy contingencies. While transit systems, and even taxicabs, are often considered in energy contingencies, such resources as school buses, church buses, and other forms of transportation are largely unknown to transportation planning organizations. This is true not only in terms of the characteristics of the services provided but also, perhaps more importantly, as to the institutional factors which make up the environment of these transportation systems.

The studies described here also point out that more thought is needed in the evaluation of contingency proposals. These studies tend to treat mobility as the most important performance measure. Planning guidance issued by the Urban Mass Transportation Administration has suggested that those energy contingency measures which both provide mobility and conserve fuel are the most

desirable.[29] A technical issue which remains is how to trade off mobility, energy conservation, cost, and other considerations in an energy contingency context.

It almost goes without saying that the behavior of travelers during energy shortages is not well understood. Further adding to this complication is the fact that behavior in non-traditional situations is of concern. For example, the community bus study technical analysis faced the problem of estimating the student modal split to school if walk distances were increased. The travel modes possible were parent drive, school bus, and walk.

Institutional Issues

The initiative for energy contingency planning in the North Central Texas Region came from an elected official on the MPO policy board. The initiative, in turn, stemmed from a belief in regional self-determination in addressing future energy shortages. In other words, this official felt that there were measures which local governments could take to mitigate future energy shortages. This is, however, a matter of political philosophy and, as such, will vary from individual to individual and from locality to locality. For a discussion of this issue, the reader is referred to an interesting paper by Wilbanks.[30]

A principal approach used in energy contingency planning is to search out and evaluate new roles for existing transportation providers. However, people and organizations are naturally resistant to changes in their roles and, thus, this becomes a major concern in energy contingency planning. In particular, the transportation providers who traditionally served only a subset of the general

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29 Frederick Salvucci, Charles Carlson, Brian Day, and David Gletner, Transportation Energy Contingency Strategies: Transit, Paratransit, and Ridesharing, Part I: Planning Process: Roles and Responsibilities. Prepared for the Federal Highway Administration and Urban Mass Transportation Administration. MIT, Cambridge, Massachusetts. March 1980.

30 Thomas J. Wilbanks, "Local Energy Initiatives and Consensus in Energy Policy." Prepared for the Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Research Council. Oak Ridge National Laboratory, Oak Ridge, Tennessee. March 1981.

public, such as school bus operators, are understandably reluctant to assume bigger and broader responsibilities. The reality of who pays for such services is, of course, part of this issue. While private enterprise may be more willing to enter new markets, it will do so only if it is profitable.

Lack of leadership is a problem. This occured in planning which involved several organizations as well as in instituting contingency transportation services. While much discussion has taken place with regard to contingency triggers, i.e., what criteria are used to institute contingency measures, these studies suggest that a more important question may be who is responsible for instituting these measures. The competition which exists between public and private transportation providers, as well as among individual providers within each sector, makes a totally centralized approach unworkable except in the most extreme circumstances.

It was found that both policy and operational issues must be dealt with in planning for energy contingencies. They must be considered when structuring the study, soliciting outside participation, selecting consultants, and formulating recommendations. Those study participants whose jobs involved overall organization policy were concerned about program costs, expanded markets, and community integration. Those individuals who were responsible for day-to-day operations were naturally more concerned about the operational difficulties of any specific proposal. Obviously, any successful proposal must address both operational and policy concerns.

In energy contingency planning, it is important to have study participants in the proper frame of mind to evaluate energy contingency measures. This was most dramatically pointed out in the community bus effort during which the 1979 summer gasoline shortage occurred. These individuals drastically changed their views toward the energy contingency planning effort and toward the viability of contingency measures when confronted with an actual gasoline shortage.

IMPROVEMENTS TO ENERGY CONTINGENCY PLANNING

Based on the findings of this study, some general recommendations are made for future energy contingency planning efforts.

Self-Determination

Successful energy contingency planning is contingent upon the belief in self-determination during energy shortages. This philosophy is entirely consistent with the current national policy of turning more responsibilities over to the state and local governments. This means that local governments will be expected to determine for themselves what happens in their local area with regard to transportation, whether it be during an energy contingency or not.

Experience with previous gasoline shortages indicates that they are, in fact, localized phenomena.[31] It is prudent, therefore, that energy contingency planning be accomplished at the state and local level. It is recommended that local transportation planners, whenever possible, deal with this self-determination concept as part of the ongoing transportation planning process.

Motivation and Decentralization

It is recommended that transportation planners recognize that activities will take place on a decentralized basis by individuals and organizations according to the motives which drive them. A single, areawide approach toward energy contingencies can serve only as a framework for individual actions, except perhaps under severe disaster conditions. This also seems to be consistent with current federal policy which looks to private and individual initiative to solve the transportation problems of today.

An appropriate mission for governments at all levels (as well as regional planning organizations) is to disseminate information to individuals and organizations which will make them more aware of their particular responsibilities and to

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31 Thomas K. Rudel, "The Geography of the American Gasoline Crises." Presented at the Annual Meeting of the Transportation Research Board. Washington, D.C. January 1982.

suggest appropriate actions. These measures must, however, be consistent with the set of motivating factors under which these organizations and individuals operate. To be more specific with regard to private transportation operators, it must be shown that energy contingency services are profitable.

Planning Methods

Generally speaking, there currently are no travel models which can (1) accurately forecast traveler behavior under an energy contingency and (2) deal with the non-traditional transportation problems which are addressed in energy contingency planning. This suggests that planning approaches which do not rely on accurate demand estimates would be most useful. Techniques such as sensitivity analysis and qualitative analysis are recommended.

Range of Issues

It was found in these studies that the full range of issues from operations to policy must be addressed in developing energy contingency plans. It is recommended that transportation planners take this into full account when developing energy contingency plans. It may be necessary to establish different advisory committees for a particular study in order to incorporate this range of considerations. This will help to assure that the overall plan will meet acceptance by all perspectives.

Contingency Frame of Mind

In order to successfully conduct energy contingency planning, it is necessary to develop and maintain a contingency mind-set on the part of the study participants. This can be done through role-playing games or personal recollections of gasoline shortages.

Another approach is to first develop plans under a "normal" situation or scenario and then to challenge the study participants to analyze the plans under an energy shortage scenario.

INTEGRATION INTO THE PLANNING PROCESS

This summary and analysis of one urban region's energy contingency planning efforts has led to some suggestions for incorporating energy contingency concerns into the ongoing urban transportation planning process. This integration of energy contingency planning is important because of several reasons. First, one of the principal constraints in planning for gasoline shortages is implementation time. By continual planning for shortages, a transportation system gradually evolves which is much more responsive to the demands of anenergy crisis. For example, transit systems can increase their fuel storage over time to help reduce their vulnerability.

As a practical matter, a separate, special energy contingency plan may be difficult to keep up-to-date, given the limited funds available for urban transportation planning. Alternatively, it is possible to incorporate energy contingency considerations into almost every planning effort. What follows are some suggestions for accomplishing this integration.

Inventory Resources

When feasible, transportation planners should expand their knowledge of the area's transportation resources. This inventory effort should include not only the characteristics of existing services but also the institutional factors which shape the nature of these services.

Utilize Alternative Systems

When new or modified transportation services are being considered, planners should investigate the use of heretofore untapped services. This will provide planners with experience in considering conventional transportation providers as well as develop a working relationship between planner and provider. Such a rapport not only will increase the effectiveness of ongoing planning efforts but also will be invaluable during any energy crisis.

Build Awareness

One of the responsibilities of a planner is to make the policy-maker aware of important trends and events. In this regard, the planner should continually keep policy boards, transportation providers, and citizens apprised of the potential for future gasoline shortages. This will require some effort on the part of the planner to monitor activities relating to energy supplies and international events, as well as state and federal regulations and programs, but this will be time well spent.

Consider Shortage Conditions

Energy shortages should be considered in evaluating transportation systems. For example, the Niagara Frontier Regional Transportation Commission included an energy-short scenario as part of an alternative analysis of major capital investments in transit.[32] Transit alternatives were evaluated under conventional travel demand forecasts. The alternatives were then evaluated under a scenario in which the price of gasoline was increased to reflect a gasoline shortage and travel demand was estimated using the higher gasoline prices. Performance measures of the alternative transit systems under both demand scenarios were used to select the recommended alternative.

A different approach has been used by the NCTCOG. In a regional plan for park-and-ride and bus preferential treatments, alternative system plans were developed which emphasized different, sometimes conflicting goals.[33] One of these system alternatives was designed to serve the greatest potential market of contingency park-and-ride users and to increase the productivity of the bus system as much as possible. This system alternative was viewed as most desirable from an energy contingency perspective. The final recommended plan combined the projects which satisfied a number of desired goals.

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32 G. W. Foster and P. C. Jenks, "An Approach to Transit Alternatives Evaluation: Phase I Alternatives Analysis in the Buffalo, N.Y. Area." Presented at the Annual Meeting of the Transportation Research Board. Washington, D.C. January, 1982.

33 North Central Texas Council of Governments, Transportation and Energy Department, Regional Park-and-Ride/Preferential Treatment Study. Arlington, Texas. July 1979.

Investigate Self-Determination

Finally, the transportation planner should investigate the community's attitudes about area self-determination in energy shortages and other transportation-related circumstances. A transportation planner's efforts must be consistent with these attitudes, if he or she is to be realistic and effective. This is an important step to take in order to integrate contingency planning into the ongoing urban transportation planning process.

APPENDICES

APPENDIX A. Alternatives Analysis Methodology

APPENDIX B. Evaluation Methodology Specifics and Examples

Source: Multisystems, Inc. and Dennis Elliott & Associates, Case Study of Community Transit Alternatives for Energy Shortages. Prepared for the North Central Texas Council of Governments. May 1980.

APPENDIX A
ALTERNATIVES ANALYSIS METHODOLOGY

This study involved the detailed analysis of a number of alternative transit alternatives operating under specified energy scenarios. Clearly it would have been possible to identify any number of alternatives and scenarios. Furthermore a wide range of potential impacts could have been assessed. Since a limited number of alternatives could be examined within the scope of this study, an attempt was made to identify those which would have the greatest likelihood of success and be most applicable in a city with few available transit resources such as Arlington. This appendix describes the methodology by which alternatives were chosen for detailed analysis, the definitions of the energy scenarios, and the impacts which were measured. It should be noted, as discussed in the previous appendix, that this investigation dealt heavily with school bus options due to their availability as a major resource. No other set of vehicles in the City of Arlington could handle large numbers of things or be so easily obtained as these.

A.1 Energy Scenarios

Community bus systems were examined in two roles, as one of many energy conservation measures and as part of an energy contingency plan. Two energy scenarios were defined. The energy conservation measures are analyzed under a situation in which no limitations exist on individual purchases of gasoline as a result of lack of supplies. Fuel is readily available, although at a price of approximately $1.00 per gallon. No external constraints, such as long gasoline lines, short service hours, or rationing limit the economic buying power of the market. This set of conditions is basically what existed as of September 1979.

Even when no crisis exists, as has occurred in the past, it is still important to reduce the amount of fuel consumed. As

such, the energy conservation alternatives have been designed to reach the following goals:

1. to reduce the consumption of fuel currently needed in the provision of public transportation services (including school buses),

2. to reduce the usage of private automobiles by diverting trips to more efficient mass transportation modes,

3. to minimize deadheading through provision of shuttle services for parking facilities, and

4. elimination or linking of discretionary trips through the reduction of automobile ownership.

The energy emergency alternatives were investigated assuming a shortfall of petroleum products amounting to approximately 15% of unconstrained usage. The 15% shortfall represents the middle of possible near term shortfall scenarios as identified by the NCTCOG.[1] In these cases, it is assumed there is no government imposed rationing other than an odd-even purchase plan and/or minimum purchases. This situation is similar to the most difficult situations which existed in the Dallas-Fort Worth area between the months of June and July 1979. The alternatives for energy contingency plans are designed and evaluated primarily for their ability to:

1. transport the increased number of persons needing public transportation in an efficient manner,

2. use only resources (vehicle and fuel) available,

3. be implemented quickly and respond to potentially abrupt changes in the level of fuel availability, and

4. provide for the needs of the most essential trips (especially work trips).

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[1] North Central Texas Council of Government, A Metropolitan Transportation Plan for National Energy Contingencies, August 1977.

A.2 Alternatives Design

The first step in the design of alternatives for a detailed analysis was the presentation of preliminary alternatives and their review by the Project Advisory Group (PAG). The set of preliminary designs included five alternatives to be examined under "normal" conditions and two additional ones to be examined under "energy emergency" conditions. The alternatives considered for normal conditions included:

1. A baseline set of actions by the City of Arlington, the Arlington Independent School District, and the University of Texas at Arlington in which each took actions in response to the needs of their own constituents. This alternative included the existing school bus routes, fixed-route service specified in the Arlington Transit Implementation Plan, and a set of UTA services for access of off-campus fringe area lots, and intra-city student commuter and non-work services.

2. A modified school bus plan in which routes were modified to eliminate some of the vehicles used and vehicle miles traveled, thereby reducing costs and fuel consumption.

3. The use of school buses or other vehicles during off-peak periods to transport the elderly and handicapped population of the City of Arlington.

4. A combination of modified school bus routes and provision of elderly and handicapped service throughout the day.

5. The addition of conventional fixed route service within the City of Arlington to alternative 4 and provision of shuttle service between the University of Texas at Arlington, off-campus park and ride lots, commercial and residential areas accessed by UTA students, faculty and staff.

More extensive options were developed in the cases of energy emergencies. These included:

1. modification of existing school bus routes to eliminate a greater number of vehicle miles than the alternative for normal conditions allowed, and

2. the provision of a coordinated service to handle all school pupils, residents of Arlington, and members of the UTA community who would need transportation in the event of an energy emergency.

These alternatives differed from those under normal conditions primarily by the degree of changes made. For example, rather than the one mile walk distance for school children to their bus stops in normal conditions, a maximum of two miles was suggested in the event of an energy emergency.

Within each alternative, several design options were offered. Modified school bus options included the use of "transportation centers"[1] requiring students to walk up to one or two miles to a location where the school bus stop, and the consolidation of similar routes each serving the same school but not fully utilized. Elderly and handicapped services employed charter subscription, doorstep dial-a-ride, and fixed route strategies to serve the variety of needs identified. Fixed route options which coordinated school and general public transportation used conventional technology (such as the routes identified in the Arlington Transit Implementation Plan) and services based on the transportation centers identified for school bus routes. Options were also identified in which fixed route services supplemented the conventional school bus system or entirely replaced it.

From the comments of the PAG, several issues were identified in which it was necessary to modify the preliminary set of alternatives. It was the opinion of the PAG that it would be unnecessary to investigate any alternatives related to the transportation of the elderly and handicapped due to the progress which had been made in Arlington's own initiatives to begin a special E&H service. The study team was to assume that such a system, consisting of five small vehicles (lift-equipped) would be operating within the city as specified by the proposal for funds as part of existing conditions.

A major constraint identified by the school district representative was in the spacing of "transportation centers". Spacings above one mile (maximum walk distance of 1/2 mile) were

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[1] L.C. Cooper, The Use of School Buses for Public Transportation, North Central Texas Council of Governments, Arlington, Texas, October 1978.

felt to be unacceptable and impossible to implement. It was further decided that the final system designs would employ transportation centers in the design of modified school bus routes rather than consolidation of existing routes. The transportation center option provided a greater degree of equity in the potential modifications while eliminating some potential discipline problems by decreasing student ride time on the bus. It was felt long ride times combined with high load factors might decrease control over children's behavior.

Finally, the decision was reached to only investigate combined general-purpose/school bus routings which employed the transportation center concept. Since only one of the available options could be subjected to a detailed analysis, more would be learned through the examination of the newer concept than the more conventional fixed route system.

These considerations led to the final system designs summarized in Table A-1.

A.3 Alternative Evaluation

The evaluation of the operational aspects of these alternatives is performed through the development of an "impact-incidence matrix". In this approach, the most important costs and benefits of a transportation system are identified along with the parties to which they are accrued (see Table A-2). Impacts are measured as they relate to three (somewhat overlapping) incidence groups including:

1) the City of Arlington,
2) the Arlington Independent School District, and
3) the University of Texas at Arlington.

Impacts identified under the UTA column are those felt by the staff, students, and administration of the University. This includes costs which are paid directly by the university or by a fee charged to students, and ridership on the transportation systems by the UTA community. The school district category is used to denote benefits and costs to public school students and

Table A-1

Alternative Community Transit Service Designs

Energy Scenario	Alternative #	Alternative Name	Description
Energy Conservation	1	Conventional Approach	Fixed Route Bus provided along TIP[1] routes by City on weekdays; Private contract provision of on-campus UTA shuttle during school year; No change to AISD service.
	2	Modified School Bus	Reduced use of school buses through route reorganization through transportation center; No service for City or UTA.
	3	Combined Transit Service	Modified school bus routes with some vehicles providing intra-Arlington transit; Transportation Center" concept employed; UTA shuttle integrated with Arlington routes.
Energy Contingency	4	Conventional Approach	Same as Alternative #1 except in energy short-fall situation
	5	Combined Transit Service	Same as Alternative #3 except in energy shortfall conditions and additional capacity provided on school and general public routes.

[1] Transit Improvement Program.

TABLE A-2 (part 1)
COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Energy Impacts				
Vehicle Miles Traveled (1000/year)				
private auto				
school bus				
transit				
Fuel Consumptions (1000 gallons/yr)				
private auto (gasoline)				
school bus (gasoline)[2]				
school bus (diesel)[2]				
transit (gasoline)				
transit (diesel)				
Monetary Costs ($1000)				
Capital				
Operating				
Revenue				
Deficit				
Mobility (1000 trips/yr)				
New Transit Trips				
Induced Trips				
School Bus Trips[3]				

TABLE A-2 (part 2)
COMMUNITY BUS SYSTEMS IMPACT-INCIDENCE MATRIX

IMPACTS[1]	INCIDENCE GROUP			
	CITY	AISD	UTA	ALL
Accessibility				
Spatial Coverage (1000 persons)				
Temporal Coverage (hours/day)				
Safety				
Street Crossings (1000/day)				
primary streets				
secondary streets				
Efficiency & Capacity				
Passengers/Vehicle Hour				
Cost per Passenger ($)				
Deficit/Passenger ($)				
Fuel Saved/Deficit (gal/$)				
System Capacity (passengers/day)				

[1] All impacts, except efficiency and capacity measures, are measured as a change from the base case in which the only public transit offered is that to the elderly and handicapped. (See Section 4.3 for a discussion of the base case.)

[2] Fuel consumed by school buses operating community bus system or UTA shuttle is listed in this category under appropriate incidence group.

[3] Includes only home-to-school trips by "eligible students" on school bus on the community transit service.

their parents as a direct result of school bus service, school bus drivers, and the district itself. All other impacts are attributed to the City of Arlington.

All impacts are measured in terms of their changes from "existing conditons." Existing conditions are those which would exist in Arlington if no additional actions were taken in response to the specified energy scenario. Therefore, the existing conditions in the energy conservation alternative consist of the travel patterns and transportation services provided as of September 1979, with the exception that an elderly and handicapped dial-a-ride service is assumed to be operated by the city.[1] In the energy emergency scenario, the existing conditions consist of the same transportation services, but the altered travel patterns which would accompany a fuel shortfall. Note that the impacts of the energy crisis on travel patterns are not explicitly measured in the energy emergency scenario tables.

A.3.1 Fuel Consumption

The first major category of impacts is the energy implications of the alternatives. Fuel requirements are measured in terms of the increase or decrease in gasoline and diesel fuel consumed. This category includes not only the fuel used in the provision of public transit services, but also change in fuel consumption by private automobiles. Fuel impacts may result from the diversion of auto drivers to transit and also as a result of trip linking in which individuals make trips more efficiently when either fuel or the automobile is unavailable.

Vehicle miles traveled and fuel consumption are measured separately for the transit service, direct diversion of travelers from their automobiles, and that resulting from changes in auto ownership. For the transit service, VMT is

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[1] AISD student travel patterns are assumed to be the same as those noted in April 1979 for which complete data are available.

based on the design specification. This measure along with fuel consumption rates for the vehicles of interest are combined to estimate fuel consumed by the transit service. (The AISD provided fuel consumption rates for school buses by type; national averages were used for other vehicle types.) Changes in private auto VMT results from direct diversion of patron to the transit service. Calculation of mileage and energy impacts are based on an estimate of passengers diverted from driving a car and average trip length. National fuel consumption rates for autos were used. Finally, in the energy conservation measures, the commitment to an ongoing transit service would convince some families to eliminate one of their autos. Results from a previous study are used to predict this impact.[1] The number of autos eliminated is assumed to be proportional to the patronage in similar areas provided with similar service. For each auto eliminated, an average of 2000 miles per year are eliminated. Care was taken not to double count this impact and that resulting direct modal diversion.

A.3.2 Monetary Impacts

Monetary impacts represent a second major operational impact of the proposed alternatives. Changes in costs and revenue will result from wages incurred in operations, direct non-labor expenditures (such as fuel, maintenance parts, and insurance), capital equipment purchases if new vehicles or modifications to existing vehicles are required, and revenue received from the farebox and through reimbursement from the state department of education. Potential federal subsidy is not included as a revenue to the city in the impact matrices. The potential revenue is discussed in the text of the next two appendices.

Monetary costs of the conventional transit alternative are estimated in accordance with the costs developed in the

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[1] Multisystems, Inc., "Benefit-Cost Analysis of Integrated Paratransit Systems," Volume 6, Technical Appendices, February 1979.

Arlington TIP.[1] The special private contracted University shuttle service is costed out at $1.50 per vehicle mile traveled. There is no charge for deadheading. For AISD operated services, the information provided in the previous appendix was used to develop a cost model based on driver hours, vehicle miles, and capital costs. In addition, special modification to the vehicle fleet and extra insurance costs are calculated separately. Revenue from services are estimated using the fare structure and number of riders in each fare category. Propensity rates from other transit properties (specifying the representation of market segments in the transit patronage as compared to their representation in the general population) are used to determine the size of each market segment.

A.3.3 Mobility

The primary user benefit of any transportation system is mobility. The diversion of trips from other modes represents the increase of mobility in that users are chosing an option they perceive as being more advantageous than that previously employed. Furthermore, some trips may be made on a transit system which previously could not have been taken at all. These represent a substantial benefit to the transit dependent market. To adequately describe the nature of the mobility benefits of the transportation system, all mobility impacts are isolated with respect to specific transit-dependent market segments. Specifically, the alternatives are evaluated on their ability to attract riders from 0-auto households, and the elderly. Other mobility impacts may be felt by school students either traveling between home and school or on field trips.

For energy conservation alternatives, method #3 presented in "Analyzing Transit Options in Small Urban Communities"[2]

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[1] Pinnell-Anerson-Wilshire and Associates, and Simpson and Curtin, Inc., "Arlington Transit Improvement Program," July 1977.

[2] Peat, Marwick, Mitchell and Co., and D.H. James, "Analyzing Transit Options for Small Urban Communities, Volume II, U.S. DOT Report IT-06-9020-78; January 1978.

(which encompasses route coverage, peak and off-peak headways, and route structure) is used to estimate total conventional transit patronage. This ridership is then divided among special market segments based on the propensity to use transit and exhibited on other transit properties.[1]

Patronage for the university shuttle service is based on analysis of time savings which could be made using the system at the headways provided. Weightings applied to rider time, wait time, and walk time[2] are used to estimate the amount of time an individual would be willing to wait for the bus. Assuming the service is provided with a high degree of reliability and students arrive on the UTA campus at random intervals, the relationship of this acceptable wait time and the headway provides an estimate of the percent of potential riders who would use the service.

No data is available on the impact of walk distance to public school bus stops and school bus patronage. In Arlington, since the walk distance under current operation is relatively large, it is assumed any increase would have only a small impact on ridership. An elasticity of ridership with respect to distance of 0.1 was assumed. During an energy crisis, this impact was assumed to be much smaller (only one third of that in normal condition).

To estimate demand under energy emergency conditions, data was gathered from the transit services operated in Fort Worth (CITRAN) and Dallas (DTS) to form a crude demand model. This data indicates that during June, July, and August 1979 (a period in which nationally there was a fuel shortfall of approximately 5%), ridership on CITRAN and DTS increased significantly (see Table A-3). CITRAN data showed a 20.7% increase during these

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1 Applied Resources Integration, Ltd., and Multisystems, Inc., Analysis of DRT Market Segments, Final Draft, October 1977.

2 Peter S. Liou, and Antti Talvitie, "Disaggregate Access Mode and Station Choice Models for Rail Trips," Transportation Research Record 526.

Table A-3

Transit Trips and Schedules Miles

	DTS		CITRAN	
Month	Revenue Passenger	Miles	Revenue Passenger	Miles
01-78	1,896,959	1,019,943	388,993	243,884
02-78	1,923,277	976,997	386,689	227,318
03-78	2,238,761	1,116,661	475,360	259,015
04-78	2,129,005	1,017,490	434,693	236,649
05-78	2,133,271	1,086,257	454,894	256,694
06-78	2,102,803	1,103,462	431,855	246,723
07-78	2,056,809	1,056,477	404,908	228,148
08-78	2,292,118	1,152,859	455,863	256,027
09-78	2,195,860	1,050,748	443,297	232,944
10-78	2,407,089	1,143,385	468,715	249,152
11-78	2,136,538	1,080,179	431,647	237,714
12-78	2,045,144	1,065,508	404,165	229,445
01-79	2,172,281	1,122,932	446,882	252,919
02-79	2,101,258	1,019,565	437,229	233,966
03-79	2,413,978	1,167,827	497,200	260,325
04-79	2,312,107	1,078,800	463,733	244,427
05-79	2,425,956	1,121,826	489,952	259,023
06-79*	2,553,445	1,083,677	499,166	247,061
07-79*+	2,401,563	1,080,078	508,913	239,316
08-79*	2,390,529	1,164,574	553,130	263,062

* Energy shortage months
\+ Fare increase implemented on DTS

months over the ridership which would have been expected were the trends for 1979 to continue. The maximum monthly increase was 25.5% during this period. The ridership increase for the first five months of 1979 over the same months during the previous year was 9.1%. For the DTS system, the ridership increased by 13.8%. The maximum monthly increase during this period was 21.4% for DTS. During the first five months of 1979, DTS patronage increased by 10.6% over the previous year. In both cases, bus miles did not vary significantly between these months in 1978 and in 1979. There was a fare increase on the DTS system in August 1979 which might have diminished the impact of the fuel crisis to some extent. Since the maximum observed fuel shortage for any one time during the summer of 1979 was approximately 15%, the project team averaged the maximum percentage increase in ridership to estimate the average impact of an energy emergency from these values the increase in riderships over the first five months of the year. From these results, the expected increase in ridership on our system is estimated to be above 13.7% that which would ride under normal conditions. Clearly, this is not necessarily an accurate model; however, no better approach was feasible due to the lack of knowledge regarding transit patronage under such severe conditions.

An alternate approach to demand estimation would be to base increased ridership on the CITRAN and DTS increases per population served. This method results in an increase of two passengers per day. This methodology does not take into account the amount of service provided in the community. Furthermore, it does not take into account that much of the travel by Arlington residents is to communities which would not be served by an intra-Arlington service. For this reason, this estimation methodology was assumed to be less valid than that discussed above.

A.3.4 Accessibility

The accessibility of a transit system provides an estimate of both the potential for individuals to use a service on an

miles traveled and the pollutant emissions. While these changes are likely to represent a minimal percentage change in the system, they do represent a potential impact to justify or prove inadequate the implementation of a marginal system. Flexibility of school administrators can be impacted if significant numbers of vehicles are employed for non-school uses. In the event of an emergency, it would be undesirable to have an insufficient number of vehicles to get children to there homes as fast as possible. (No significant changes in flexibility were noted with respect to the alternatives analyzed, therefore, this category was dropped from the impact-incidence matrix.) The provision of transit services within the community will have an impact on the employment of the community. The need for more drivers may provide some unemployed persons with some degree of employment, or could simply convert part time jobs into full time ones for those needing an additional income. This study estimated service quality including walk distance, ride times, and wait times on the general public and school services. All these are estimated based on the location of route, bus stops, and residences and likely destinations of passengers. The results of the service quality measurement proved not to be significant; therefore, this result is not presented in the impact incidence matrices.

A more complete explanation of the methodologies used in evaluating the operational impacts of these services is provided in Appendix B. This appendix also illustrates these calculations by using the third (and most complex) alternative as an example.

APPENDIX B

Evaluation Methodology
Specifics and Examples

Calculation of Transit Vehicle Miles

Step 1: Estimation of Route Miles

This step was performed by measuring route distances on each route off a map. For Alternative #3, the round trip lengths were calculated to be:

Route #	Peak Length (miles)	Offpeak length (miles)
1	21.8	13.5
2	29.2	20.5
3	24.5	19.5
4	32.7	21.5
5	32.9	19.0
6	19.8	19.8
7	32.4	-

Step 2: Transit VMT per Year

The route miles were then multiplied by the number of runs per day during each period and the days per year.

For Alternative #3:

Peak Mileage		Peak Runs		Off Peak Mileage		Off Peak Runs		Days		Total Transit VMT
(193.3	x	8	+	113.8	x	6)	x	251	=	559,529.2

Step 3: Attribute to School, City, and University

VMT is next divided into City, AISD, and UTA components. These are based on map measurements. For Alternative #3, each vehicle passing through the UTA campus averages 1.8 miles more than if a direct path were used. With 14 runs per day on each of the two routes during 216 days per year, 21,773 miles are attributed to UTA. There are a total of 43,188 miles of the route for which the school district can be reimbursed by the State. This mileage was assigned to the AISD for calculation of costs also. The remaining 494,568 miles are charged to the City of Arlington.

Calculation of Transit Fuel Consumption

Total transit VMT divided by vehicle fuel consumption rate equals total fuel consumption.

For Alternative #3: (in which all vehicles were 84 passenger diesel powered school buses), the calculations were performed as follows:

CITY: 494,568 miles/8.5 miles per gallon = 58,185 gallons.
AISD: 43,188 miles/8.5 miles per gallon = 5,080 gallons.
UTA: 21,773 miles/8.5 miles per gallon = 2,562 gallons.

Fuel consumption rates for various vehicles are listed below. Fuel consumption rates for school buses were provided by the AISD. Fuel consumption rates for a conventional bus, for a 20 passenger bus, and private auto were based on national projections for 1980.[1]

Calculation of Transit Pollutant Emissions

Emission rates for 84 passenger school buses are 27 grams of carbon monoxide per mile, 4.5 grams of hydro carbons per mile, and 20.1 grams of nitrous oxide per mile. These figures were provided by the U. S. Environmental Protection Agency. For Alternative #3, this results in a total emission of:

Pollutant	Emission Rate (g/mi)	Miles/Year			Kg/Year		
		CITY	AISD	UTA	CITY	AISD	UTA
CO	27.0	494,568	43,188	21,773	13,353	1,166	588
HC	4.5	494,568	43,188	21,773	2,226	194	98
NOx	20.1	494,568	43,188	21,773	9,942	868	438

Vehicle Type	Fuel Type	Fuel Consumption Rate (mile/gallon)
19 passenger school bus	gasoline	8.5
36 passenger school bus	gasoline	6.3
48 passenger school bus	gasoline	5.2
72 passenger school bus	gasoline	4.5
84 passenger school bus	diesel	8.5
20 passenger school bus	diesel	7.5
43 passenger school bus	diesel	6.0
8 passenger school bus	gas	16.9

[1] Source: "Benefit-Cost Analysis of Integrated Paratransit," Volume VI, by Multisystems, Inc. February 1979, p. 54.

Calculation of Transit Vehicle Hours

Step 1: Calculation of Running Times

Road tests were performed by members of the project staff on a variety of routes to estimate running speeds along the various routes. The results of these tests were used to develop the following vehicle run times per round trip:

Route Number	Peak Round Trip Miles	Off-Peak Round Trip Miles	Running Speed	Peak Run Times	Off Peak Run Times
1	21.8	13.5	22.4	58.3	37.0
2	29.2	20.5	20.6	85.0	59.7
3	24.5	19.5	20.6	71.4	56.8
4	32.7	21.5	22.2	100.8	58.1
5	32.9	10.0	22.2	88.9	51.4
6	19.8	19.8	17.0	69.9	69.9
7	32.4	--	19.2	101.3	--

Step 2: Calculation of Pickup/Dropoff Time

Ridership and number of bus stops were used to calculate the time required to pickup passengers. 0.27 minutes were allowed for each vehicle stop plus 0.06 minutes per passenger. Passengers are estimated in the mobility section of this appendix.

For Alternative #3:

Route Number	Peak Stops	Off-Peak Stops	Peak Passengers Per Run	Off-Peak Passengers Per Run	Peak Pickup Time	Off-Peak Pickup Time
1	19	12	15.0	13.3	4.2	2.9
2	27	18	18.9	16.8	5.9	4.2
3	26	23	21.8	19.3	5.8	5.2
4	36	21	21.2	18.8	7.5	4.9
5	32	18	18.8	16.7	6.7	4.2
6	16	16	35.3	31.4	5.0	4.8
7	27	--	25.9	--	6.3	--

Step 3: Addition of Layover Time

The average run time on these routes turns out to be 88.1 minutes during the peak and 59.8 minutes in offpeak hours. Therefore, layover time was added into the runs to bring the

total round trips scheduled times to 90 and 60 minutes. As a result, there are a total of 56 ninety minute runs and 36 sixty minute runs per day. Annual vehicle hours therefore total 30,120. An additional 5% is added to driver hours for extra-boards, and check in and check out times. Driver hours total 31,740 hours.

These hours were divided among the three groups as follows:

CITY — 25,840
AISD — 3,477
UTA — 2,403

This was based on the timings made of the various routes.

Calculation of Transit Costs

For service provided by the school district, the existing cost structure was used to estimate a cost model. Drivers wages are based on the necessary driver hours. The base pay is $3.70 per hour. In addition, Workmans' Compensation and life insurance adds an additional 5.4% for fringe benefits. Regular vehicle maintenance, tires and outside repairs were charged on a per vehicle-mile basis. In addition, capital costs and administration would be charged to the city for the service on a per vehicle mile basis although these costs would not actually change. Using a figure of 841,000 miles of regular bus service derived from AISD provided data, the cost per vehicle mile was estimated at $.388. Fuel costs were based on fuel consumption at $1.00/gallon for gasoline and $0.95/gallon for diesel fuel.

For Alternative #3, the total costs were estimated as:

	Driver Hours		Vehicle Miles		Fuel Consumed		Cost
CITY:	25,840 x $3.90	+	494,568 x $.388	+	58,185 x $.95	=	$347,799
AISD:	3,477 x $3.90	+	43,188 x $.388	+	5,080 x $.95	=	$ 35,143
UTA :	2,403 x $3.90	+	21,773 x $.388	+	2,562 x $.95	=	$ 20,254

To this figure is added new charges for public transit insurance in the CITY column. (Note AISD can legally provide UTA transit service without additional insurance.) This amounts to $5,400 per vehicle or $75,000. Also, new capital

costs are required in the modification of the vehicles. This amounts to $500 per fare box installation plus $2000 for seat modifications per bus. The resulting $35,000 is amortized over a seven year period for an annual capital cost of $5,000.

Calculation of Accessibility of Transit

This calculation was made by identifying the population density around each stop served and assuming the population was uniformly distributed around the stop. Population density is based on the 1980 estimate of population by census tract performed by the NCTCOG.
Areas of census tracts were estimated from available maps.

For the baseline alternatives, each route was considered to cover an area one half mile across along the route for the general public and 1/4 mile across for the elderly and handicapped. Overlaps of coverage between routes were eliminated. In the transportation center alternative, each transportation center covers a circular area 1/2 mile in diameter for the general public and 1/4 mile in diameter for the elderly and handicapped. Since the existing conditions were assumed to have a special handicapped doorstep service, the fixed routes provided no additional coverage for this group.

The area of coverage for Alternative #3 (and others) are available in note form, the length of text to describe each transportation center's coverage makes it impossible to include in this appendix.

Calculation of Transit Patronage

Step 1: General Public Total

Transit patronage by the general public was made using method #3 of the "Analyzing Transit Options in Small Urban Communities."[1] The first step of this method is to determine the number of persons living within 1/4 mile of bus stop. (This is

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[1] Peat, Marwick, Mitchell and Co., and D.H. James, "Analyzing Transit Options for Small Urban Communities, Volume II, U.S. DOT Report IT-06-9020-78; January 1978.

the same as the accessibility measures, but the overlap is not eliminated to account for the greater accessibility and better service provided by multiple routes.) For each route, a base ridership is derived from Figure V-6 of the Peat Marwick, Mitchell report[1] from this coverage and the number of elderly persons included in the covered population. The base ridership table was calibrated from observed relationships between coverage and system patronage. This base ridership is then adjusted for the following characteristics:

- o number of stops on one way loops
- o peak headway
- o off-peak headway
- o days of operation, and
- o transfer coordination.

In Alternative #3, this leads to the following calculations:

Route No	1	2	3	4	5	6	7
Population Covered	7,494	11,235	11,235	12,079	12,920	12,718	10,973
% Loop Rate	42	38	47	38	60	0	31
Peak Headway	45	45	45	45	45	45	45
Off-Peak Headway*	60 (60%)	60 (80%)	60 (90%)	60 (85%)	60 (60%)	60 (95%)	--
Days of Operation	Mon.-Fri.	Mon.-Fri.	Mon.-Fri.	Mon.-Fri.	Mon.-Fri.	Mon.-Fri.	Mon.-Fri.
Transfer Coordination	Avg.	Avg.	Ave.	Avg.	Avg.	Avg.	Avg.
Base Annual Riders	45K	170K	195K	188K	194K	190K	170K
Loop Factor	0.94	0.95	0.91	0.95	0.87	1.50	0.98
Peak Headway Factor	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Off-Peak Headway Factor	0.83	0.88	0.92	0.89	0.84	0.93	0.70
Service Days Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Transfer Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Total Annual Ridership	50.5K	63.4K	22.8K	70.8K	63.3K	117.4K	52.0K

[1] The figure in parentheses in the off-peak headway indicates the portion of the route which is covered during off-peak hours.

Step 2: General Public Market Segments

The resulting ridership was broken into market segments including the elderly and youth under 16 based on the propensity to ride transit[1] (ratio of market segment representation among patronage to its representation in the general public) from other transit services and the size of these groups within Arlington. For the elderly, the propensity of use is 0.64 and their representation in Arlington is 4%. As a result, 2.56% of the ridership is elderly. Children from 5-16 represent approximately 19.5% of the Arlington population and have a propensity to use transit of 1.21 (average over several systems, including Boston and national estimates).[2] This yields 23.6% of the patronage being from this group.

Data from another study[3] indicates that approximately 8.8% of the general public transit ridership would not have made the trip were the transit service not available. This figure was used to estimate the total number of induced trips. Using a methodology employed in the "Benefit-Cost Analysis of Integrated Paratransit,"[4] induced trips were further broken down into elderly and no-auto households. These groups are estimated to take 70% of all induced trips with these divided in proportion to their occurrence in the ridership. The estimates of the no auto household riderships was based on the

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1 Applied Resources, Ltd. and Multisystems, Inc., "Analysis of DRT Market Segments," Draft Final Report, October 1977.

2 Note no systems had figures on this particular market segment, most were reported for under 20 or under 24 years of age. These were used to estimate this propensity.

3 Ewing and Wilson, Innovations in Demand Responsive Transit, MIT Center for Transportation Studies, 1976.

4 Multisystems, Inc., et al., "Benefit-Cost Analysis of Integrated Paratransit," Volume 6, proposed for the Transportation Systems Center, U.S. DOT, February 1979.

propensity of transit ridership of this group (3.15).[1] For Alternative #3, the following calculations were performed:

Induced Trips = 8.8% of total trips = 0.088 x 490,500 = 43,354

Trips by Elderly = 12,500 (from previous calculation)

Trips by No Auto Househould members = propensity x % in population x total trips = 3.15 x 0.035 x 490,500 = 54,077

Induced Trips by Elderly= Induced Trips x 0.7 x trips by elderly/(trips by elderly + trips by no auto household members) = 43,254 x 0.7 x 12,500/(12,500 + 54,077) = 5,685

Reduced trips by no auto = induced trip x 0.7 - induced trips by elderly = 43,254, x 0.7 - 5,685 = 24,592

Step 3: Total UTA Ridership

UTA ridership was based on estimated use of parking facilities, number of parking spaces in these lots and time characteristics of the service provided.

First it was estimated that the distant parking lots are on an average 36% full (based on the 15% of the time at which they are at full capacity). This indicates that at any one time, roughly 900 of the 2500 spaces are in use. Further assuming that an average person using these lots spends 3 hours at school, there are 3150 potential users of the intra-campus service (each making two one-way trips).

The average walk time to campus from these lots is estimated at 5.0 minutes and the average ride on the shuttle of 3.5 minutes. Using a weighting of 1.0 on ride time, 1.3 on walk time and 1.6 on wait time to calculate the impedance of walking or using the shuttle, people would be willing to wait up to 1.9 minutes for the shuttle.[2] (Above this level, there is a greater impedance on using the shuttle than to walking to

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1 Applied Resources, Ltd., et al., "Analysis of DRT Market Segments," October 1977.

2 Peter S. Liou and Antti Talvitie, "Disaggregate Access Mode and Station Choice Models for Rail Trips" Transportation Research Record 526.

campus.) If a bus comes by every 22.5 minutes during the peak and every 30 minutes off-peak, (average headway of 26.8 minutes) on a reliable schedule and students arrive at the lot at random, approximately 7.0% of the potential users would wait for the shuttle (1.9 divided by 26.8). This represents an average daily ridership of 441 persons, or 95,364 annually.

Calculation of Revenue for Transit Service

Based on the predictions of ridership characteristics, there are 1,954 revenue passengers per day on the community bus system. Of these, 2.6% are elderly and 23.7% are children. Assuming no transfers, the average fare is 34.74¢. At this fare, revenue from patrons amounts to $170,365 (1,954 passengers per day and 251 days/year x 0.3474) for Alternative #3.

Transit Service Quality

Step 1: Estimation of Average Transit Trip Length

Since transit covers an area of approximately 48 square miles, the geometric probability relationship that the length of a random trip in the area equals approximately half the square root of the area covered indicates the average direct trips distance is 3.46 miles long. Using the factor 1.273 to account for circuity in the street network, this average trip distance was estimated to be 4.4 miles. This distance applies along the regular street network, using the best route. The circuity of the community routes adds an additional 1.15 miles to the length of the trip. This is calculated as half the average one-way route length (since almost all demand will be destined to the major employment and shopping centers at the end of the route). During peak hours in which 60% of passengers ride, the one way route distance is 6 miles. During off peak, it is 4.9 miles. The average bus ride is 5.55 miles.

Step 2: Estimation of Average Ride Time

The total vehicle miles traveled divided by the vehicle hours provides the average speed on all routes. For Alternative #3, this is 494,568 miles over 25,840 hours or 19.0 miles per hour. Therefore, the average travel time is 19.0 minutes.

Step 3: Estimation of Average Wait Time

The average wait time is estimated at half of the average headway. In most areas, the headway between vehicles in the peak is 45 minutes and in the off-peak is 60 minutes. Also, a quarter of the trips made, mostly between the center of the city and the industrial park could take two or more buses. This quarter of the ridership perceives even better service. Weighting these headways by their ridership, the average perceived headway for Alternative #3 is 39.8 minutes with 60% of riders using peak service and 28% able to take either of two buses (based on route overlaps).

Calculation of UTA Shuttle Service Quality

Ride time was estimated based on detailed investigation of the location of stops and travel speed. Wait time was half the headway for the service based on the scheduled (22.5 mninutes peak headway, 30 minutes off-peak headways). Walk distance was calculated at one quarter the distance between stops.

Calculation of Transit Jobs and Payroll

In Alternative #3, the direct increase in the transit service provides an additional 28,243 hours of work for bus drivers. (This excludes the portion of the service attributed to the school district but not to the UTA.) This is an average of 112 hours per day with at most 14 drivers assigned at one time. As a result of this scheduling, 19 part-time jobs are created average 6 hour shifts per day. The payroll amounts to $104,529 at $3.70 per hour (note this does not include the Workmans' Compensation and life insurance costs built into the cost estimation procedure).

Changes in Auto VMT and Fuel Consumption

Step 1: Diversion of Auto Drivers

To determine the impacts of auto travel on automobile drivers, diversion statistics were averaged to determine the percent of transit riders who previously had driven their cars. The estimate was that 28% of all riders had previously driven. For Alternative #3, this amounts to 547 people who previously would have driven an average of 4.4 miles (as discussed previously).

Step 2: Changes in Auto Ownership

The results of a previous analysis of providing conventional bus service in a city with characteristics much like those in Arlington (a sun belt city) resulted in one auto being eliminated for every 1817 riders generated by the transit system.[1] This figure was then applied to the transit ridership generated. In Alternative #3, with 490,500 riders, this amounts to the elimination of 270 cars. (Note this impact will not results from a short lived contingency transit system.)

Step 3: Calculation of Change in Auto VMT

In the same study for which impacts of auto ownership were estimated, the impact of this reduction in auto ownership was estimated at 2000 miles per year per car eliminated. This amount would include some of the trips which are now taken by former auto drivers. For this reason, the number of trips made by persons eliminating their cars must be subtracted from the previous auto drivers now taking transit. To estimate these trips, a transit trip production rate per day 0.53 per person who uses transit is multiplied by the total number of persons eliminating their autos.[2] In Alternative #3, this is 0.53 x

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1 Multisystems, Inc., et al., "Benefit-Cost Analysis of Integrated Paratransit," Final Report, Volume 3, February 1979, pp. 110 and B-9 (Setting 3 was used).

2 From Rochester, New York data.

270 = 143.6. This means that 540,000 miles per year are eliminated by persons who get rid of their cars and 445,649 miles per year eliminated by persons who previously would have driven and do not eliminate an automobile (1,954 x 0.28 - 143.6) x (4.4 miles x 251 days).

Step 4: Elimination of Chauffered Trips

Finally, a number of trips previously made only to serve the needs of the passenger will be eliminated. National figures indicate that 42% of the transit patrons previously would have been passengers of a private automobile, of these, 25% would have been chauffered with no other purpose for the trip.[1] Since each of these trips on transit would eliminate a trip in both directions, the impact is doubled that of drivers. The auto VMT eliminated by this method is 8.8 mile x 251 miles x daily ridership x 42% x 25%. In this alternative, the daily ridership if 1954, therefore 453,179 miles of auto travel are eliminated.

Adding in this change in VMT, the total change is 1,439,826.

Step 5: Calculation of Fuel Consumption

National averages indicate as of 1980, the average fuel consumption for private automobiles should be 16.95 miles per gallon.[2] This figure applied to Alternative #3 reduction in auto VMT results in a fuel savings of 84,890 gallons of gasoline.

Calculation of Fuel Savings from the UTA Shuttle

As indicated before, the maximum time a person would be willing to wait for the shuttle would be 1.9 minutes per trip. This amount of wait time is equivalent to an extra 3.0 minutes of ride time of which some might be used to search for a new

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1 Multisystems, "Benefit-Cost Analysis of Integrated Paratransit".

2 DeLeuw Cather, Characteristics of Urban Transportation Systems, 1975.

parking place. Clearly, on an average, the shuttle service would not be expected to eliminate this entire amount of driving. It was assumed 50% of this time looking for a parking space would be reduced. At 10 miles per hour and 6.7 miles per gallon, the fuel saved in Alternative #3 amounts to 1,756 gallons (2.96 minutes x 0.5 / 60 minutes per hour x 10 miles per hour / 6.7 miles/gallon x 47,700 outbound trips per year).

Calculation of Change in Auto Emissions

Emission rates projected for 1980 automobiles[1] and the VMT changes calculated above were used to calculate the total reduction in pollutants. The table below indicates these emission rates and the VMT changes derived for Alternative #3.

	EMISSION RATE (g/mi)				EMISSIONS (kg)		
	VMT	CO	HC	NOx	CO	HC	NOx
City	-1,439,826	45	6	3	-64,792	-8,638	-4,319
UTA	-11,765	45	6	3	-529	-71	-35

Calculation of School Bus VMT and Fuel Consumption

Step 1: Assign Students to Transportation Centers (TC's)

Using AISD data indicating the streets on which each bus route traveled and the number of students riding the bus, the number of students expected to be picked up at each transportation center was recorded. If more than one transportation center fell along a given run, the total number of students on that run were divided in accordance with the length of the route near each appropriate transportation center. These transportation center loadings were segregated by elementary, junior high, and high school students.

Step 2: Develop routes between TC's and schools

Using the loadings from the step above, routes were developed identifying the travel by each bus. These routes were developed in order to minimize route mileage, fill buses nearly to capacity, and have as much reimburseable mileage as

1 Ibid.

possible. These routes were developed by eye. No change was made to the existing special student runs. The appropriate size vehicle was assigned to each run based on the maximum number of students on the bus at one time.

In Alternative #3, only those students not able to use the combined transit routes were assigned to the separate system. As a result, Alternative 3 required

4-36 passenger buses,
6-48 passenger buses,
21-72 passenger buses, and
3-84 passenger buses.

It is not possible to describe these routes in detail within this appendix.

Step 3: Calculation of Total VMT

The route mileages were measured on the map to indicate mileage from the garage, along the full route, and back to the garage. These mileages were then added by vehicle type to develop a route mileage profile. The same measurements were made for the existing AISD school routes. The difference in mileage was then calculated by vehicle type. The table below lists these results for Alternative #3.

	Annual Vehicle Miles Traveled		
Bus Type	Existing Routes	New Routes	Difference
19	16,625	24,922	+8,296
36	5,205	28,765	+23,561
48	26,645	64,203	+37,558
72	426,940	165,094	-261,846
84	56,861	20,311	-36,550
TOTAL	532,290	303,295	-228,995

An additional 43,188 miles per year of the combined routes (which were to be reimbursed under the State of Texas school bus funding formula) were attributed to the school district. These miles were all performed using 84 passenger buses.

Step 4: Calculation of Fuel Consumption

Fuel consumption rates from AISD recods were used to convert chang in VMT into change in fuel consumption. These calculations for Alternative #3 are illustrated below:

Vehicle Type	Change in VMT	Fuel Consumption Rate (mile/gallon)	Change in Fuel Consumption (Gallons)
19	+8,296	8.5	+976
36	+23,561	6.4	+3,681
48	+37,558	5.2	+7,223
72	-261,846	4.5	-58,188
Total Gasoline			-46,308
Diesel:			
84	+6,638	8.5	+780

Note the 84 passenger bus mileage includes that on the combined service.

Calculation of School Bus Emissions

Emissions rates from the U.S. Environmental Protection Agency (obtained in a telephone conversation) were used to calculate the total emissions from school bus operations. The table below lists these rates and illustrate the calculations for Alternative #3.

Vehicle Capacity (seats)	VMT	Emission Rate (g/mi) CO	HC	NOx	Emissions (kg/yr) CO	HC	NOx
19	+8,296	34.5	2.5	2.4	+268.2	+20.7	+19.9
36	+23,561	94.7	7.9	4.4	+2231.3	+186.3	+103.7
48	+37,558	104.3	8.7	4.4	+3,916.8	+326.7	+165.2
72	-261,846	93.6	8.2	5.0	-24,508.	-2,147.	-1,309.
84	+6,638	27.0	4.5	20.1	+179.2	+29.9	+133.4
					-17,895.	-1,584	-861.

Calculation of School Bus Reimbursement

The state reimbursement for school bus operations was determined based on the 1979-80 reimbursement formula (75¢ per approved mile). Reimbursement mileage for new bus routes were measured on a map with each regular bus route traveling from the school of origin through its specified route and their returning to the school of origin. Base case reimbursement was calculated directly from reimbursement mileage recorded by the AISD. Total base case reimbursement mileage was 2184.6 miles per day. In Alternative #3, the reimbursement mileage amounted to 1319.7 miles per day. At 177 school days per year, the

difference amounts to $114,810. Note in this calculation that local routes receive no reimbursement and special routes do not change.

Calculation of School Bus Costs

Step 1: Determine Separate School Bus Hours

The average vehicle speeds and the number of stops for each bus routes was used to calculate the travel time required for each separate school bus route. This calculation is exactly the same as that discussed for the transit routes previously; therefore, this discussion will not be repeated here. Total change in vehicle hours for Alternative #3 was 24,313 less.

Step 2: Costs of Separate School Bus Routes

Using the difference in vehicle hours, vehicle miles, and gallons of fuel between existing conditions and the separate service, the change in cost was calculated using the previously defined cost formula. For Alternative #3, this calculation is as follows:

-228,623 VMT x $.388 + -46,308 gal. gasoline x $1.00+
-4085 gal. diesel x $.95 + 24,313 hours x $3.90 = $233,715.

Step 3: Add in Combined School Costs

In Alternative #3, the combined routes were partially used for school bus service. The $35,143 calculated previously must be added to the cost of school bus service, bringing the total to $220,163.

Calculation of School Bus Jobs and Payroll

In Alternative #3, there is a reduction of 24,313 hours per year of separate school bus service and in increase of 3,477 hours of service for school bus on the combined portion of the transit service. This combines for a loss of 20,836 hours of work per year for school bus operation (or $77,093 at 3.70 per hour). Assuming a 6 hour work day 251 days per year (or 8 hour day 177 days per year) this amounts to 15 jobs.

Calculation of Accessibility

Under existing conditions, all eligible students live within ¼ mile of a bus stop (by school district policy). In the case of using transportation centers, the distribution of students (based on density of the street network) indicated that approximately 60% of eligible students live within a quarter mile of the transportation centers. This estimate was developed by sampling various areas in the city. Since TC's were centrally located with respect to the population of the area each serve, the resulting coverage measures higher than a 50% estimate which would be derived if the population were assumed to be uniformly distributed. With approximately 6400 students eligible for bus transportation, 2560 students no longer live within a quarter mile of a transportation center.

Calculation of School Bus Ridership

The only factor influencing ridership in this analysis was the increased walk distance to the bus stop. The elasticity of school bus ridership with respect to walk distance was assumed to be -0.1 in energy conservation alternatives and -0.033 for energy contingency cases.

For Alternative #3, the average walk distance (all students) was increased from 0.057 mi to 0.150 (by estimation on a map). With 4960 students impacted by the route changes, the change in ridership is

$$4960 \times -0.1 \times \frac{.093}{.057} = -810 \text{ students.}$$

With two rides per day and 177 days per year, this amounts to 286,740 fewer trips taken.

School Bus Safety

While calculating the average walk distance, the number of streets crossed were also counted. This was performed by estimating the number of streets crossed for th average walk to each transportation center. These estimates were than weighted

by the number of students at each stop to determine a system-wide average. For the existing condition, six routes were examined to determine the average number of streets crossed.

Using transportation centers, the average number of streets crossed per student is 0.76 primary streets and 2.04 secondary streets. To regular school bus runs, the estimates were 0.024 primary and 0.539 secondary street. This output is presented in terms of thousands of trips per day.

Calculation of Student Auto Transportation Impacts

Step 1: Determine Additional Private Auto VMT

With 810 students no longer taking the school bus to school, it is necessary to estimate the resulting auto travel now provided by the parent. It was assumed that 75% of the diverted students would be chauffered to school by parents with no other purpose for the trip. The remaining 25% of students no longer using the bus would be taken on the parents way to work or shopping. The average length of a student bus trip was measured at 3.25 miles through sampling of 10 existing routes. The distances were measured on a map of the area. Therefore, the parents chauffering students would travel an average of 6.5 miles twice per school day (177 per year). For students transported along with other trips, it was assumed the diversions would add only 0.75 miles to the parents trip. In both cases, it was assumed that an average of 1.5 students would be transported per car.

In Alternative #3, chauffered auto mileage increases as follows:

+810 students x 75% / 1.5 students per car x 6.5 miles x 2 trips per day x 177 school days per year = 931,904 miles

For the remainder of the sudents, VMT is calculated as follows:

+810 students x 25% / 1.5 students per car x 0.75 miles x 2 trips per day x 177 school days per year = 35,842 miles

Thus the total change in auto VMT from this impact is +967,745.

Step 2: Change in Fuel Consumption

At 16.94 miles per gallon, this change in VMT increases fuel consumption by 57,128 gallons of gasoline.

Step 3: Change in Emissions

The associated pollutant emissions are as follows:

Pollutant	Emissions Rate (g/mi)	Annual Emissions (kg)
CO	45	43,549
HC	6	5,806
NOx	3	2,903

School Bus Service Quality

Step 1: Estimation of Change in Walk Time

Using a map illustrating the street density, an estimate was made for the walk distance to each transportation center. The weighted average of these distances, based on the number of students using each TC, was then calculated. For Alternative #3, the average walk distance was 1.5 miles. In the existing conditions, the average walk distance was estimated by sampling the walk distances to ten existing routes from the areas they serve. As a result, an estimate of 0.057 miles was calculated for the base case. Change in walk distance for Alternative #3 is therefore 0.093 miles.

Step 2: Estimation of Ride Time Change

The ride time for students was measured on the specified routes based on average running speeds of the routes. This was performed for both existing conditions and for the transportation center based routes. It was estimated the routes traveled at approximately 16 miles per hour when transportation centers were used, and 12.5 miles per hours under existing conditions. Average ride distances were 3.3 miles and 3.6 miles with transportation centers and existing conditions, respectively. This difference results in a decrease in average travel time of 4.9 minutes.

Capacity of the System

Capacity of the community transit system was developed assuming a 100% load factor on all parts of the routes attributed to the city. Therefore, with 48 seats per vehicle and 1971 miles of routes per day operated in Alternative #3, the potential seat miles is 94,948. Since the average passenger rides 5.55 miles on the system, the system capacity is 17,105.

For the UTA service, there are fifty-two trips per day through the campus in Alternative #3. If each bus were filled on each of these runs both to and from campus, there could be as many as 4990 students using the bus per day. Note this value does not account for any regular passengers on the bus as it travels through the campus.

Capacity of the separate and combined school bus runs is calculated in terms of the number of students carried per day. (Note this is half the total number of trips since two runs per day.) The total number of seats available per run multiplied by the number of runs by each vehicle equals the capacity. In Alternative #3, there are 89 runs with an average of 58 seats per run (assuming 3 students per bench). Total system capacity is 5,166 students or 10,332 trips per day.

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